VAN NOSTRAND'S
ECLECTIC
ENGINEERING MAGAZINE.

NO. XV.—MARCH, 1870.—VOL. II.

THE BESSEMER PROCESS UNDER PRESSURE.

From "Engineering."

IT has long been known to Bessemer steel manufacturers that certain of the purer qualities of Swedish pig-iron, made with charcoal, and also some of the less

FIG. 1

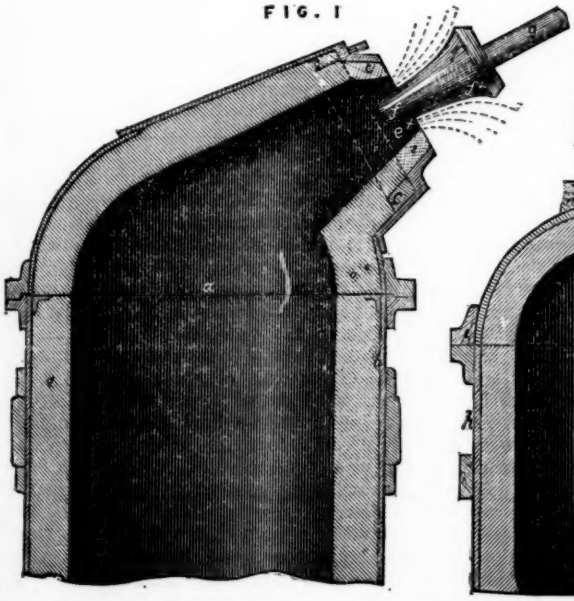
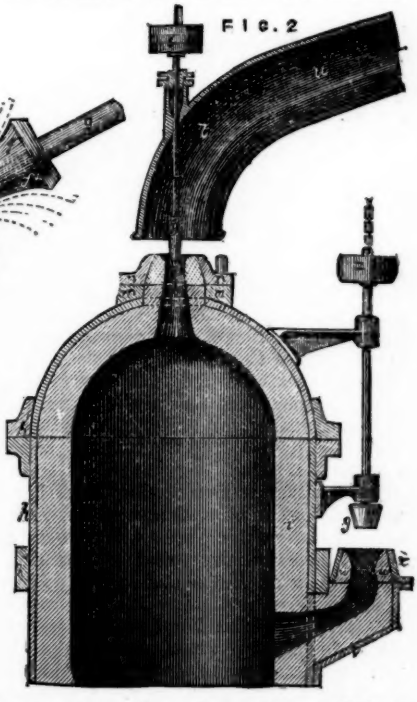


FIG. 2



gray and the white hematite pig-irons of this country, when treated by the Bessemer process, do not produce sufficient heat in the converting vessel, under ordi-

nary circumstances, to allow all the steel made from them to retain complete fluidity until it is poured into moulds, and hence it sometimes happens that large "skulls" or shells of solidified steel are left in the casting ladle. This evil is increased when malleable scrap-iron, or steel in a solid state, is added to the charge of metal in the converter.

To obviate this inconvenience, and to raise the temperature of the metal during the process of conversion so high that no skull or solidified metal shall be left in the casting ladle when employing carburets of iron not rich in graphitic or other carbon, Mr. Bessemer has lately schemed and patented the method of conducting his process under pressure, which we are about to describe—this method enabling the manufacturer to use many qualities of iron that do not produce a maximum of heat under the ordinary converting process, and also enabling him to put into the converting vessel a portion of steel scrap or scrap iron, or other kinds of decarburized or malleable iron in a solid state; which, by means of the extremely high temperature imparted to the metal, become fused and form part of the charge of molten malleable iron or steel obtained. For this purpose Mr. Bessemer makes the converting vessel of great strength, securely riveting and caulking all the laps and joints so as to render it air-tight as near as may be; and he, by preference, forms the mouth of the vessel circular instead of oval, and of a smaller size than usual, lining the mouth with a single ring of well-burnt fire-clay or composition of clay and plumbago. He also forms the metal part of the mouth of the converter with a movable dovetailed flanged ring, so that the fire-clay mouth of the vessel may be readily taken out and renewed by unbolting or uncottering the iron ring which retains it in place.

In the annexed engravings, Fig. 1 is a vertical section of a Bessemer converter constructed on this plan, *a* being the upper part of the converting vessel; $a^{\times}$, the lining of ganister; and *b*, the strong riveted iron shell or vessel on the inside of the mouth of which the iron hood, *c*, is riveted; while *d* is a flanged iron ring, bevelled on the inside, and secured by screwed studs or cotter bolts to the hoop, *c*. A moulded ring, *e*, of fire-brick or other suitable refractory material, forms the escape opening or mouth of the vessel; it is retained in place by means of the flanged ring, *d*, and when it is worn out or damaged, the ring, *e*, may be renewed by unfastening the ring, *d*, a mixture of fire-clay and ganister being first smeared over those parts of the ring, *e*, which come in contact with the lining, a^*, and with the bevelled interior of the ring, *d*, for the purpose of making the joint air-tight.

The aperture in the movable mouth of the vessel thus formed may in some cases be made small enough to retain the gaseous products resulting from the combustion of the carbon or other matter contained in the pig-iron under a pressure much above that of the surrounding atmosphere, so that the combustion going on in the converting vessel may be under "high pressure," as described in our account of Mr. Bessemer's new melting furnaces, which appeared on pages 187 and 197 of our last volume. The contraction of the mouth of the vessel would in this case be greater than is shown in Fig. 1 for the purpose of retaining the gaseous products under considerable pressure, so that the gaseous products resulting from the combustion of carbon and other matters in or among the fluid metal would be prevented from expanding freely; and by reason of the combustion so taking place under a pressure much greater than that of the external atmosphere, a more intense heat would be produced and imparted to the metal.

The amount of pressure thus obtained should vary with the heat producing properties of the carburet of iron operated upon and the quantity of scrap or other unfused metal forming part of the charge, so that no precise rule can be laid down as to the pressure to be employed; but as a guide to the workmen, Mr. Bessemer states that for the conversion of the purer kinds of Swedish charcoal pig-iron and for mottled or white hematite pig-iron mixed with gray, a back pressure in the vessel from 8 to 15 lbs. on the square inch will give good results, and in but few cases will a pressure of 20 lbs. per square inch be necessary; while a pressure as low as 3 or 4 lbs. will be but of little practical advantage, and below 2 lbs. per square inch he lays no claim to as a useful effect. It will be understood that the pressure of the blast of air forced into the converting vessel must be increased in

proportion to the back pressure caused by the penning up of the gases within the vessel.

Mr. Bessemer, however, remarks that the mode of obtaining the required back pressure by simply diminishing the outlet does not offer all the desired facility of regulating the pressure from time to time during the process, while at the same time the accumulation of slags in the aperture may in some cases reduce the area of outlet so much as to retard the inflow of air through the tuyeres. For these several reasons the opening in the mouth of the converting vessel may be made much too large if left open to retain the gaseous matters in the converter at the high pressure desired, such larger sized mouth being provided with a conical stopper inserted in the opening and so arranged as to be advanced or further withdrawn by being itself movable or by the motion of the vessel on its axis, the vessel being made to advance towards or recede from a fixed conical stopper. Mr. Bessemer, however, prefers to use a movable conical stopper attached to the end of an iron rod, as shown in Fig. 1. The conical piece of fire-brick, *f*, is circular in form, and spreads outward in a curved line at *f**, for the purpose of deflecting the flame and preventing its too powerful action on the iron rod, *g*, which supports the cone, *f*. The rod, *g*, protrudes through the back wall of the converting house, or may be supported on a bracket or piece of iron framing in connection with the standards which support the vessel, and by means of a screw or lever, the cone, *f*, is made to advance further into or recede from the mouth of the converter, thus increasing or diminishing the area of the annular opening at *e**, and regulating the pressure of the confined gases in the vessel.

In some cases it may be found desirable to render the stopper, *f*, self-acting by applying a spring or weighted lever to press it forward against the pressure of the escaping gases, so that, either by reason of its enlargement by the accretion of slags on its surface, or by being partially burned away, it will occupy such a position in the mouth of the vessel throughout the process as will give a sufficiently equal amount of back pressure, and prevent that pressure from exceeding what is necessary by any partial clogging up of the escape opening; or in lieu of employing a conical stopper, a flat or other shaped surface may be employed, the object in either case being to enlarge or contract the opening for the escape of flame as found desirable at different stages of the process. The pressure of the confined gaseous products is indicated by a mercurial column arranged as described on page 15 of the present number. This gauge will allow the workman to employ from time to time such an amount of internal pressure in the vessel as the known qualities of the material he employs may render necessary.

When crude molten iron or remelted pig or refined iron is decarburized or partially decarburized or converted into refined iron or into malleable iron or steel by the action of nitrate of soda or potash, or by other oxidizing salts, or when such decarburation or conversion is effected by any other processes in which the decomposition of nitrate of soda or potash, or other oxygen-yielding salts alone or mixed with metallic oxides, takes place in or below the fluid metal in a converting vessel or chamber, a large amount of heat is absorbed and rendered latent, thus tending to solidify the metal and rendering it unfit for forming into ingots or castings without being remelted.

To obviate this and raise the temperature of metal (while so treated or converted) to such a degree as to allow it to be cast into ingots or other cast articles or masses prior to its solidification, Mr. Bessemer proposes to construct the vessels in which the process is to be carried on of great strength, preferring to use stout iron or steel plates well riveted and caulked, and, if needful, further strengthened by stout hoops. The mouth of the vessel is to be made very small, Mr. Bessemer preferring for that purpose to employ a well-burned fire-brick ring, into which a long taper cone of the same material is placed. The cone is fastened to a long rod working in suitable guides, so as to keep it central with the mouth of the vessel. The space between the exterior of this cone and the interior of the fire-clay ring determines the area of outlet for the gaseous products given off during the time that the decomposition of the nitrate or other oxygen-yielding materials is going on, and a weight or spring lever, acting on the rod to which the fire-clay cone is attached may be made to regulate the

amount of pressure required to lift the cone and permit the escape of the gaseous matters.

The arrangement of which we have just spoken, is illustrated in Fig. 2, which represents a vertical section of the upper portion of a converting vessel or chamber in which molten pig or other carburet of iron is to be treated either by the injection of the fluid nitrate into the molten metal, as patented by Mr. Bessemer in March last, or in which vessel the nitrates or other oxygen-yielding salts or substances are so brought into contact with the hot metal as to be decomposed. The outer shell, *h*, of the vessel or chamber, is made of thick plates of iron or steel, securely riveted and caulked at all joints, and capable of withstanding safely a pressure of from five to ten or more atmospheres. For the convenience of lining the vessel, the upper part may be removed by unbolting the stout flanges, h^1; and one or more hoops, h^2, are riveted to the exterior of the vessel to strengthen it. A lining of fire-brick, ganister, or other refractory material, *i*, is used to defend the outer shell from the high temperature generated within; and previous to its use for conversion, Mr. Bessemer prefers to make a fire in the interior so as to highly heat the lining and lessen its power of absorbing heat from the metal.

On the upper part of the dome an iron ring, *m*, is riveted, to which a flanged ring, *n*, is fitted. The inside of this ring is conical and is made to embrace the conical fire-clay ring, *p*, through which the gaseous matters evolved during the process are allowed to escape. A cone of fire-clay or of iron, *g*, is attached to the guide rod, *r*, for the purpose of closing or diminishing the area of the outlet opening in the fire-clay ring, *p*, and on the upper end of the rod, *r*, are placed weights, *s*, to regulate the pressure. The rod, *r*, is guided vertically upward and downward by passing through the tubular guides and stuffing-box formed at *t t*, on the curved exit passage, *u*, which leads to a chimney and conveys away the gaseous products escaping from the converting chamber. On one side of the vessel or chamber is a projection, *v*, on the upper part of which a ring of fire-brick, *w*, is retained in place by a conical flanged iron ring, *x*. The opening in the ring, *w*, serves for the admission of the molten metal to the vessel, after which the cone, *y*, smeared with fire-clay, is lowered down into the opening of the moulded fire-brick, *w*, and by means of the weight, *z*, is retained in place and prevents the escape of gaseous matters during the converting process.

The cone, *y*, and its rod and weight, *z*, are suspended by a chain in the position shown during the period of running in the metal. When the metal so run in comes in contact with the nitrate or other oxygen-yielding materials, large volumes of gaseous matters are evolved, these matters, instead of escaping freely from the converter, rapidly accumulating in the vessel until the pressure within it is sufficient to raise the cone, *g*, and escape by the small annular opening thus made, the pressure being regulated by the weight, *s*. Hence the combustion of the carbon contained in the molten iron, by reason of its union with oxygen derived from the decomposition of the nitrates or other oxygen-yielding materials, will be effected under considerable pressure; and the gaseous products, instead of expanding freely as under the ordinary conditions of combustion, will be in a highly condensed state, by which means their temperature will be considerably raised, and the intense heat so generated will be imparted to the metal and cause it to retain its fluidity.

Dr. Mayer, the celebrated physicist, has now perfected an instrument he calls a dynamometer, which, adapted to engines of 20-horse power and upwards, reads simultaneously measurements of force in the form of heat as well as of pressure. We have no account as yet of the instrument, which is obviously of more scientific than practical value. The same philosopher, dealing with the question of the conservation of force, has come to the conclusion that the large amount of force which is lost in the form of heat in all mechanical operations can never be utilized. Heat, he tells us, is the cheapest possible form of force, mechanical is far dearer, and electricity the dearest force of all. Hence it would never pay to transform waste heat into any other form of force.—*Mechanics' Magazine.*

In exploring the caves at Wellington, N. S. W., the remains of various extinct animals have been discovered.

ON THE LABORING FORCE OF THE HUMAN HEART.

From "Nature."

There is no organ in our bodies that has a more important influence upon health, at all ages of our lives, than the heart, whose rhythm and force are governed by laws of nerve force, of which we are at present almost totally ignorant. Regarded, however, from a mechanical point of view, as a hydraulic pumping machine, our knowledge of the heart is more accurate, and may yet lead the way to greater knowledge of the physiological action of this vital organ.

I propose, in the present communication, to give an estimate of the daily laboring force of the human heart, and to compare it with that of other muscles, such as those used in rowing or climbing, reserving for a future communication the proof of the data to be now employed.

The heart, regarded as a pumping machine, consists of two muscular bags (*ventricles*), one of which drives the blood through the lungs, and the other through the entire body. This blood is forced by a pumping action, repeated seventy-five times each minute, through both lungs and body, and experiences in each case a resistance which is measured by the hydrostatical pressure of the blood in the pulmonary artery and aorta. The resistance offered to the circulation of the blood by the capillary vessels of the lungs and body, is different; but the total quantity of blood that passes through the lungs and body in a given time must be the same; from which it follows, that the resistance offered by the capillaries must be in the proportion of the hydrostatical pressure in the great arteries leading from the ventricles of the heart. If, therefore, we knew that pressure for one side of the heart, and the relative forces of the two ventricles in contracting, we should know the entire resistance overcome by the heart at each of its beats.

If, in addition to the hydrostatical pressure in one ventricle, and its ratio to that in the other ventricle, we knew also the quantity of blood forced out of each ventricle against this pressure, we should have all the elements necessary to calculate the laboring force of the heart, as will be presently shown.

I demand, therefore, that my reader shall grant me, provisionally, the following postulates, which are necessarily three in number:

I. That three ounces of blood are driven from each ventricle at each stroke of the heart.

II. That the hydrostatical pressure in the left ventricle and aorta, against which the blood is foced out, amounts to a column of blood 9.923 feet in vertical height.

III. That the muscular force of the left ventricle, in contracting, bears to that of the right ventricle the proportion of 13 to 5.

With these postulates granted, we may now proceed to calculate the daily laboring force of the heart as follows: At every stroke of the heart, three ounces of blood are forced out of the left ventricle against a pressure of a column of blood 9.923 feet in height. The work done, therefore, at each stroke is equivalent to lifting three ounces through 9.923 feet. This work is repeated 75 times in each minute, and there are 60×24 minutes in the day. Hence, the daily work of the left ventricle of the human heart is $3 \times 9.923 \times 75 \times 60 \times 24$ ounces lifted through one foot; or since there are 16 ounces in the pound, and 2,240 lbs. in the ton, the work done by the left ventricle of the heart in one day is $\frac{3 \times 9.923 \times 75 \times 60 \times 24}{16 \times 2{,}240}$ tons lifted through one foot. Multiplying and dividing out this quantity, we find the daily work of the left ventricle is 89.706 foot tons. The work done by the right ventricle is five-thirteenths of this quantity (post. III.); the daily work of the right ventricle, is therefore 34.502 foot tons. Adding these two quantities together, we find for the total daily work of the human heart 124.208 tons lifted through one foot.

It is not easy for persons unaccustomed to these calculations to appreciate quickly the enormous amount of laboring force denoted by the preceding result; but in order to facilitate this appreciation, I shall compare it with the following descriptions of labor:—

1. The daily labor of a working man.
2. The work done by an oarsman in an eight-oar boat race.

3. The work done by locomotive engines, or animals climbing a height.

1. The daily labor of a working man, deduced from various kinds of labor, from observations spread over various months, is found to be equivalent to 354 tons lifted through one foot, during the ten hours that usually constitute the day's work. This amount of work is less than three times the work done by a single heart, beating day and night for 24 hours: thus, three old women sitting beside the fire, alternately spinning and sleeping, do more work by the constant beating of their hearts, than can be done in a day by the youngest and strongest "navvy."

2. If an Oxford eight-oar boat be propelled through the water at the rate of one knot in seven minutes, the resistance offered by the water may be estimated at 81.36 lbs. by calculation, or at 74.15 lbs. by actual observation. From this result, and from the fact that 575 ounces of muscle are employed by each of the eight oarsmen, we can calculate that 15 foot-pounds of work are expended by each ounce of muscle during each minute of work.

No labor that we can undertake is regarded as more severe than that of the muscles employed during a boat race; and yet this labor, severe as it is, is only three-fourths of that exerted day and night during life by each of our hearts.

The average weight of the human heart, which increases with age (for obvious reasons), may be estimated from the following tables:

	Average oz.
1. Meckel	10.0
2. Cruveilhier	7.5
3. Bouilland	8.4
4. Lobstein	9.4
5. Boyd (æt. 30—40)	10.4
6. Boyd (æt. 40—50)	10.5
Mean	9.39

From this weight, and the work by the heart in one day (124 foot-tons) we can calculate the work done by each ounce of the heart in one minute, as follows:

Work done by the human heart, in foot-pounds per ounce per minute,

$$\frac{124.208 \times 2240}{9.39 \times 24 \times 60} = 20.576 \text{ foot-pounds.}$$

This amount of work exceeds the work done by the muscles during a boat race (as already stated) in the proportion of 20 to 15, or of 4 to 3.

3. There is yet another mode of staing the wonderful energy of the human heart. Let us suppose that the heart expends its entire force in lifting its own weight vertically; then the total height through which it could lift itself in one hour is thus found, by reducing the daily work done in foot-tons (124.208) to the hourly work done in foot-ounces, and dividing the result by the weight of the heart in ounces:

Height through which the human heart could raise its own weight in one hour =

$$\frac{124.208 \times 2240 \times 16}{24 \times 9.29} = 19754 \text{ ft.}$$

An active pedestrian can climb from Zermatt to the top of Mont Rosa, 9,000 feet, in nine hours; or can lift his own body at the rate of 1,000 feet per hour, which is only one-twentieth part of the energy of the heart.

When the railway was constructed from Trieste to Vienna, a prize was offered for the locomotive Alp engine that could lift its own weight through the greatest height in one hour. The prize locomotive was the "Bavaria," which lifted itself through 2,700 feet in one hour; the greatest feat as yet accomplished on steep gradients. This result, remarkable as it is, reaches only one-eighth part the energy of the human heart.

From whatever mechanical point of view, therefore, we regard the human heart, it is entitled to be considered as the most wonderful mechanism we are acquainted with. Its energy equals one-third of the total daily force of all the muscles of a strong man; it exceeds by one-third the labor of the muscles in a boat race estimated by equal weights of muscle; and it is twenty times the force of the muscles used in climbing, and eight times the force of the most powerful engine invented as yet by the art of man.

No reflecting mind can avoid recognizing in its perfection, and regarding with reverential awe, the divine skill that has constructed it.

The most powerful fog-whistle in America is at Cape Fourcher, N. S. It can be heard 15 miles in clear weather and 25 with the wind.

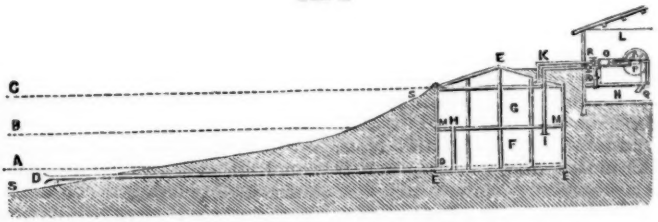
THE TIDE-MOTOR.

Condensed from "Annales de Genie Civil."

An Italian engineer, M. F. Tommasi, has just patented in France and elsewhere a Motor, called Le Flux Moteur, which uses the fall of the tide as a motive power. We give an abstract of the first chapter of the Memoir published by M. Tommasi, in which he explains the principle, construction, and application of his invention.

If the water of the sea is conducted into a reservoir by means of a horizontal tube set at the main level of low water at the spring-tide, the bottom of the reservoir being at the same level with the tube, and its top being at a level with the base of the *unit of height* of the tide (A B D F, Fig. 1), it is obvious that this reservoir will always contain water, and that its level, rising

FIG. 1.

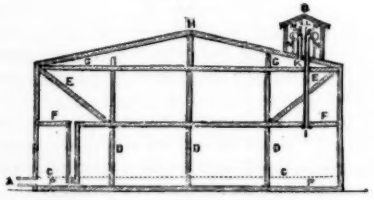


A, mean level of low water at spring-tide; B, base of *unit of height;* C, mean level of high water at spring-tide; F, lower reservoir; G, upper reservoir; H, pipe to upper reservoir; I, pipe to motor apparatus; K, pipe connecting with discharge pipe of motor apparatus; MM, horizontal partition; N, storage reservoir; O, cylinder; P, pump.

with the sea, will be at its extreme height when the sea is at the mean of its ascent; provided that there is a suitable orifice of discharge for the air which fills the reservoir, so that it can escape when the water enters.

But if, on the contrary, this reservoir is closed, the enclosed air, in preventing the water from rising, will suffer a pressure proportional to the relative height of the sea. It follows that, by connecting the upper portion of the reservoir with a motive apparatus, by means of a tube, the

FIG. 2.



VERTICAL SECTION OF RESERVOIR.—A, tube connected with the sea; B, pipe carrying water to upper section; C, minimum level; D, E, frame; F, horizontal partition; I, pipe to motor apparatus; K, pipe connecting with discharge pipe; M, manometers; N, tubes connecting the several reservoirs.

piston will be driven with a force proportional to its area and the tension of the air; a tension proportional to the weight due to the charge of sea water. By making the area of the piston proportional to the work required, and the tension of the air at the time the level of the sea has reached a certain point, it will result that from this point to the limit of the flood height, the piston will always move with the same force; since the reservoir level rises with the sea level; and, the difference always being the same, the pressure of air and the work resulting will be constant.

If, during the operation of the motor, the water from the sea freely enters a reservoir placed above the other, having its upper surface at the height of spring-tide (C H M, Fig. 1); and if the plug is closed, when this reservoir is filled, the ebb will leave it full of water, and when the sea has sunk so far that, relative to its maximum level, it has the same head as it had at first relative to its mimimum level, the work of the water suspended in this reservoir is equal to the work of the sea-water when it had risen to the given point. Now, by connecting the upper portion of the reservoir by means

of a tube with the discharge pipe, the external air, in entering, will drive the piston with a force proportional to its area, and to the rarefaction produced on the other side by the weight of the descending water. Since this weight is equal to that which has compressed the air in the other reservoir, it is equal to the pressure of the external air. From this time to the end of the reflux, the piston will move with the same force, since reservoir level and sea level descend alike; and the difference being constant, the pressure of the air, and hence the power generated, will be constant.

Now, if before the work ceases, which happens when the upper reservoir is empty, the valve at the upper portion of the lower reservoir communicating with the air is opened, the water will descend with the sea level. When the tide rises, the valve is closed, and the operation is repeated.

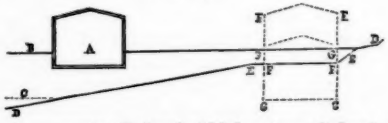
In using the apparatus described above, each period of work must be followed by one of repose. The hours of work vary with each day; and hence the motor is suited to those industries only in which it is not necessary to have steady power; for example in machines for raising water, saw-mills, etc.

When steady power is desired, the apparatus is modified. Another reservoir is added as a storage reservoir (cloche de réserve), and pumps are used to condense air. This is operated when men are off work (as in the night and on Sunday); and by means of these pumps it fills the storage reservoir with condensed air. If the tide has not reached a point suitable for direct application of its work, power can be obtained from this form of the tide-motor by stopping all of the pumps and one of the cylinders, and making connection with the storage reservoir. This will furnish condensed air for work until the tide has turned so as to furnish its power direct.

The reservoir is of wood, braced with oak and securely hooped. Its wall is of pitch-pine plank, and saturated with tar. The height of the cylindrical portion should be about half a metre more than twice the height of the *unit of tide*. The horizontal partition should be half a metre above the middle of the cylinder.

The diameter theoretically depends upon the amount of pressure required; but it would be convenient to establish a constant diameter of say 20 metres; as this gives great capacity without difficulty of construction, and the fixed dimensions would cheapen future constructions.

FIG. 3.



A, reservoir ; B, level of high water ; C, level of low water ; F, reservoir set at high tide above its bed ; G, final position of reservoir.

When the reservoir is finished it is launched, and towed to its station. A bed, E, 23 metres wide, starting at the level of the highest tide, and extending toward the sea, so far that its lower level is horizontal, is dug in the sand, to a depth equal to the draught of the reservoir. This should be dug at ebb tide. At flood the reservoir is moved to its place, F. At low tide a trap is opened in the ceiling, workmen descend, and, taking up the floor (not yet fastened), pass out the sand toward the sea side so that the reservoir becomes firmly fixed. When the base has reached the point G, the flooring is replaced and calked.

A trench is now dug seaward, half a metre below mean low-tide level, in which is laid a red cedar pipe, bound with wire hoops, gutta-percha-coated, with joints of oak. This tube is so disposed that the sea end is above the bottom; but it is never out of water, so that the sand cannot choke it. Notwithstanding this precaution, should this happen, the slight inclination will cause the tube to be scoured out at each ebb; or the reservoir can be discharged for this purpose.

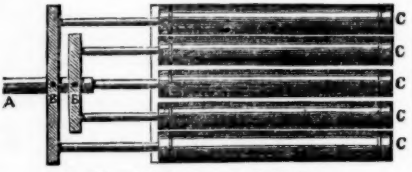
The pipe, being set, is covered with sand; the planks of the horizontal partition are set and calked; the vertical tube from the upper chamber is placed; the reservoir is closed hermetically; connection is made with the motive apparatus, and the motor is ready to do work.

Certain peculiarities of construction in the motive apparatus are necessary. (1.) The dimensions of the cylinder should be large, because of the low pressure on the piston. (2.) A regulator would obviously be useless. (3.) The stop-cocks are of a kind specially adapted for this purpose.

In order to transform the intermittent

motive force into a continuous work, it is only necessary to have an air-tight storage reservoir large enough to furnish the motive power during the time when the tide cannot work directly.

FIG. 4.



B, Movable bolts. C, Cylinders.

The compresso-motor apparatus should have two cylinders. The piston rod should drive directly five pistons. The two cylinders of the motor-pistons and the ten pumps should be of double effect. Upon the rod of the two motor-pistons is fixed the cam for transmitting the motion to the crank. The fly-wheel for regulating the motion should be of great size and little weight. Each group of five pistons should be divided into two couples and one independent piston, so that the number at work can be regulated. Each pump should be supplied with two stop-cocks, by means of which, communication may be made with the storage reservoir or with the external air. The motor pistons should be set so as to be detached from the crank, so that the motive apparatus can be worked without the pumps. The apparatus will be more clearly understood by reference to the illustrations.

The inventor claims that the Tide-motor will, for obvious reasons, cheapen manufactured products; that the compressed air can be conveyed for use to great distances by means of pipes; that the power is uniform and constant; that it is free from danger; and that it affords the advantages sought for in attempts to invent a perpetual motion.

THE FAIRLIE ENGINE.

[The following, from a correspondent, is a timely answer to the inquiries of many correspondents concerning this engine.—ED.]

The readers of this magazine have seen, since its opening, numerous accounts of this locomotive, but perhaps some have not been aware that there was one building in this country. This has been constructed in the shops of Mr. Wm. Mason, Taunton, Mass., from original designs of Mr. Fairlie, Americanized by Mr. Mason. This engine is 56 ft. long, and has 12 driving wheels, with, therefore, a rest of 5 tons upon each wheel. Her boiler has the appearance of two ordinary locomotive boilers turned fire-box to fire-box. These fire-boxes being separate; the steam space, and such part of the water space as allows 6 inches of water to lie upon the centre of the crown-sheet (upon whatever grade she may be) being connected. Two smoke-boxes, two smoke-stacks, each at the end of the boiler; two steam domes, two safety-valves, two bells, etc., each in their usual place upon the apparent two boilers. In the centre, over the fire-boxes, is the cab. Inside this the throttle lever works horizontally in circular guides, upon a vertical axis, raising puppet valves in the steam domes simultaneously. It is placed on the top centre of the boiler, and is useful from both sides. A hand-wheel upon each side works the link. Levers duplicated work the sand-box and cylinder cocks. The blower-rods are doubled that the engineer may stand on either side of the boiler. The coal-breakers are four in number, two just outside each end of the cab. Upon the boiler and frame are securely fastened water tanks of sufficient capacity, which, though connected, contain 4 water holes.

Upon a simple cradle, formed of two long slabs, firmly bolted to the boiler, and two inverted saddles of cast-iron, the boiler rests. To the two saddles the centre pins are attached, working upon the centre of the truck with a ball and socket action. There are two other inverted saddles upon the frame, over that end of each truck which is nearest the fire-boxes, to which are attached bearing surfaces, which rest and slide easily upon surface bearings upon the ends of the trucks, with a side play of about 8 inches. There are elliptic springs upon each side of the centre pins, and volute springs to ease the bear-

ing surfaces upon the inside ends of the trucks. Three wheels, of 3½ ft. diameter, support each side of each truck, giving a wheel base of 8 ft. 3 in.

On the outside ends of each truck are two cylinders, with all their connections; each cylinder working the three wheels, two flanged and one bald; the latter is of course the centre wheel. These cylinders receive their steam from a pipe which passes vertically from the smoke chamber to a stuffing-box upon the top of the truck; from this stuffing-box another pipe with a hollow ball attachment within the stuffing-box, runs forward into a stove; from this stove another pipe passes still forward, with another hollow ball attachment in another stuffing-box. These balls work in the stuffing-boxes as rockets and in the stove by sliding. At the second stuffing-box, the steam pipe is divided, and passes through the casting, forming the front of the truck to the cylinders. The exhaust is handled in about the same manner. Other devices may be used for making the steam pipes flexible, but this seems to answer remarkably well in practice and to improve by use.

For expansion and reversion the sink is used; the fact, that in all angles the centre of the truck remains a fixed point, allows a fulcrum to be placed there with only one "knuckle-joint" to give ease to the rods, which handle easily. Pilots and brackets for head-sights are placed at each end, and she is always ready to start in either direction. As the tanks are so close, there is no need of an extraneous pump, the injectors answering every purpose; and as one sink is up when the other is down, the counter weight, or usual spring, is dispensed with. There are 4 fire-doors, and the blowers may be be put on from either side.

Counting her as one engine, she has nearly double the number of pieces as an ordinary locomotive, and is so much more complex. Counting her as equal to two, she is more simple in the frame, with less need of pumps and without necessity of counter weights. There are also four less wheels, with their axles, boxes, slides, springs, and equalizers. There is no tender to haul, the equivalent for it aiding her power by additional adhesion. Brakes are worked upon each truck from the cab.

The appearance is prepossessing, giving a greater idea of power than is presented by the old locomotive. The motion is exceedingly pleasant, consisting almost exclusively of rising and falling in long low curves, with no perceptible side oscillation. Indeed she appears to possess a wonderful faculty for keeping the centre of the track, or else of touching the rail so lightly and sheering off so smoothly as to leave her transverse motion unfelt. The same principle seems to apply to her passage over the ordinary cast-iron frog, and around several reversions upon turnouts of unknown but sensibly small radii. In all cases her motion was so peculiarly soft in comparison with that of the ordinary engine, as to suggest at once a considerable decrease in the item of repairs, both to rolling stock and permanent way.

Another peculiarity is the power she possesses of throwing her centre of gravity nearer to the centre of the curve in proportion to the shortness of the radius, thus counteracting the force tending to throw her outwards in somewhat the same manner as it is done by animate beings.

The writer of this article had gone to Taunton to examine the engine, and has spent some time studying her construction while she was being put together, and her action under steam. But there was still another desideratum. What would she do with a train of freight cars? The difficulty was to get cars enough upon the light grades around Taunton. For, if an ordinary Bajie engine of the same capacity of cylinder (15×22 stroke), could pull 30 8-wheel cars from Taunton to Mansfield, she should pull just 90; or, if the first could do a daily work of 25, she should do a daily work of 75. And 75 cars, much less 90, were not to be got together. The only way to do then was, to start her with the usual train (she has the masculine double-faced name of Janus), and judge her simply by her style of handling it. This was done on Friday, January 28. The load was equal to 26 cars (8-wheeled). Suffice it to say of an experiment, so far from what was to be desired, that they were handled easily on main track and switch with the valves cutting off at an allowance of 3 in. of steam, and a pressure never greater than 117, and mostly down to 82 or 85 lbs. Her consumption of coal seemed to be

economical, but circumstances did not allow of accurate tests.

Her easiness of management was fully tested, and was most satisfactory. Her power was not tested. On some of our mountain roads, where gradients and curvatures combine to produce resistance, her peculiarities could be fully developed and examined. We suggest this to some road. Mr. Mason has well done his part.

The writer, having had occasion to notice that the instance of the Fairlie engine "Little Wonder" upon the Festiniog Railroad, had apparently begot a mental connection in the minds of several well-known and intelligent engineers, between the Fairlie system and the very narrow gauges, begs to offer a few suggestions: The cheapening of the construction of roads by the adoption of this system would, for a time at least, be confined to branch roads. Although our knowledge of the economy with which narrow gauge roads (2 and 3 ft.) in Norway and other countries are run, is beyond dispute. We should remember that in this country it would be cumbered with the necessary unloading and reloading of freight at the junctions, and with, of course, an additional number of cars. Our late changes of gauge, though made in one direction, were not so much in deference to economy of running as to the economic convenience of connection. A car once loaded is paying in proportion to the distance it travels, and losing in proportion to every change in the position of its centre of gravity in any useless direction. Thus the benefit of the system might be fully counterbalanced, if after a haulage of 10, 20, or even 50 miles, this centre of gravity was lifted vertically and then set down upon another train. Then, without throwing aside advantages which might accrue from a narrow gauge, these principles might be safer to start upon. That if a Fairlie of 30 tons weight with 12 drivers, and therefore a weight of 25 tons upon each wheel, will traverse curves of say 300 feet radius, or less, at a fair rate of speed; iron may in the first place be purchased corresponding to the weight of wheel in goods wagons (also about 27 tons), instead of being arbitrarily determined by the 5, 6, or 7 tons driver weight of the present locomotive, so as to be either doubly heavy and costly or one half as lasting. The saving in graduation by the use of the above stronger curvatures would vary with the contour of the country, and might easily vary from 0 to 60 per cent. of the present cost. The saving in the raising and repacking of crossties would also be important; so would be the saving in engineers' wages, turn-tables, turn-table labor, and turn-table repairs and renewals. Further, by adding the steam car, and drawing less non-paying to paying load, thereby a still further reduction would be made in the expenses of small lines and short-distance accommodation trains. Altogether the system is eminently worthy of thought and experiment.

MISSOURI.

ART IN ENGINEERING.

From "The Building News."

Nothing is more curious in the history of Architecture than the way in which its various changes and different phases have succeeded each other. It would seem that these changes have followed each other in an almost, if not quite, insensible way, like fashion in dress; and this went on in quite a natural and regular manner though all the Gothic styles, from the earliest to the latest. It did so with the Renaissance and the older styles of architecture; but in these modern days, by a singular series of what may be almost termed accidents, this natural mode of inventing and developing a style of art has been completely reversed, or, rather, put aside, and instead of the natural growth of the Gothic or any other single and simple style of architecture, it has come to pass that out of every phase of Gothic, and out of every phase of the Renaissance, a sort of *compo* architecture has risen up, meaning nothing whatever and expressive of nothing. But by the side of all this, and irrespective of it, there has been going on a style of building, as we must call it, consequent on the needs of the railways in their taking the place of the common high roads, which might, if left to itself, have created a style

of architecture peculiar to the age, and really expressive of its wants and modes of thought. Unfortunately, this has been prevented by the employment by our civil engineers, whenever any architecture has been thought necessary, of the professional architect, or, rather, his assistant, who has been called in to add the architectural features to the mere construction. This most curious state of things is exemplified in the two railway bridges over the Thames at Hungerford and Blackfriars, and the two new bridges at Westminster and Blackfriars. These structures show the constructional work of the civil engineer and the art work of the architect combined, or, rather, simply brought together as if by accident. It is a kind of work and mode of doing it so peculiar to the time, that a few thoughts about it may not be uninteresting nor uninstructive.

But before we can do this it is necessary to remind the reader of the nature of the older and primitive architectures, and to see how very simple they were originally as they grew, in each country, out of the constructional knowledge and requirements of those who used them, and out of the materials at their command. Be it well and constantly borne in mind that any one old style of architecture was simply the growth of the art faculty of the executive artists of the time out of the simple construction, while in these modern days it is the importation, from a foreign source, of the art element, and its amalgamation, foreign though it be, with the building construction; while in engineering, as we have said, it is the mere fixing or gluing on to the constructional forms the architectural and fine art decoration. It is only by accident that the architecture in a railway bridge forms any part of the necessary constructional building. And this it is that leads to the consideration, very shortly, of the different styles of simple architecture, and to a short definition of architecture as a fine art and means of adding the grand idea of beauty to the necessary quality of utility.

We may, then, to make our meaning as clear as possible, define architecture to be the individual expression, in each age and country, of the wants and feelings of men as influenced by the climate, materials, and vegetable and animal life in each country.

And under the general term Architecture we would also include sculpture, when forming, as it always should do, a part, and a necessary and vital part, of the architecture, and also all decorative art, as wall painting. .

The arts of sculpture, painting, and the decorative arts, have in all countries, when not corrupted by foreign influence, followed the architectural arts.

The architecture of the world may be most conveniently and simply divided into two great and leading divisions or orders, viz.: First, the architecture of walls, piers, or columns, covered by a lintel or a flat roof, and by a gable roof; second, the architecture of walls, piers, or columns, covered by arches, either round or pointed, and by a gable roof more or less steep.

The intermediate style of walls, piers, or columns, the round arch and the lintel, forms a style composed of both the others; it arose from the discovery, or invention, or use of the round arch by the introduction of it between the columns of the earlier architectures and their lintel.

Under either one of these three heads we shall find that all the styles of architecture that have at any time appeared in the world may be ranged, or that can ever appear, and that the only real distinction there is or can be between them may be resolved into a difference in the mode of their ornamentation. It will thus be found that what at first seems of a nature the most complicated and difficult is easy of comprehension, thus:

To the Lintel order of architecture belong, in the order of their date, the Egyptian, Assyrian and Persian, Hindoo, Chinese, Greek, Etruscan, in the Old World; and Mexican and Peruvian, in the New World.

The architecture of Ancient Rome was the link which joined together the two great and primitive orders, by the introduction and use of the round arch. It belongs more properly to both divisions, rather than as forming a distinct style. In the architecture of Ancient Rome, the temples, as that of Jupiter Stator, belong to the first, and the aqueducts, triumphal arches, etc., to the second. But the latter, in strictness of division, belong, as I have said, to both also; as in them are for the first time found the three grand constituent elements of all architecture—

the column, the arch, and the lintel. The full development of the Arch architecture is first seen in the Romanesque, when free of the lintel. Its perfection is first seen in the Early Gothic.

To the Arch order of architecture belong, in the order of their date, the Roman; Romanesque, in all its varieties; Arabian, or Moorish, as it is sometimes called; Gothic, in all its phases; and the Renaissance, or, Revived Roman (not Greek) architecture, or Italian, as it is usually called; and the whole of that wide school of styles of which theElizabethan,or Italo-Gothic of England, may be cited as an instance. The whole of the architectural styles, from the fifteenth century till the revival of the Gothic in our own day, is to be classed under the general term of the Renaissance. Mr. Wornham has classed no less than seven distinct varieties.

By carefully observing this simple division, we shall at all times be provided with a key map, so to speak, whereby each one of the architectures may be referred to its proper division, and any collection of architectural examples will be readily understood, and their place known by referring them to the varieties or subdivisions of the leading or primitive styles. A correct and strictly scientific division, it will be evident, is an all-important matter in the arrangement and easy understanding of any collection. It is all-important, too, in the arrangement of a catalogue or explanatory class-book.

Mr. Ruskin has adopted, in his classification of the styles, a somewhat different division from that which I have done, but perhaps hardly so clear and distinct. It seems almost a pity that he is so one-sidedly attached to a special phase of southern Gothic. In this northern climate we seem to be unable to do anything with it. It has failed completely.

Pugin can hardly be said to have attemped any analysis of architectural styles generally. He interested himself in nothing but the Gothic, and that chiefly of his own country. It is very greatly to be regretted that he did not live to more completely work out and perfect his own peculiar phase of Gothic—almost a creation of his own.

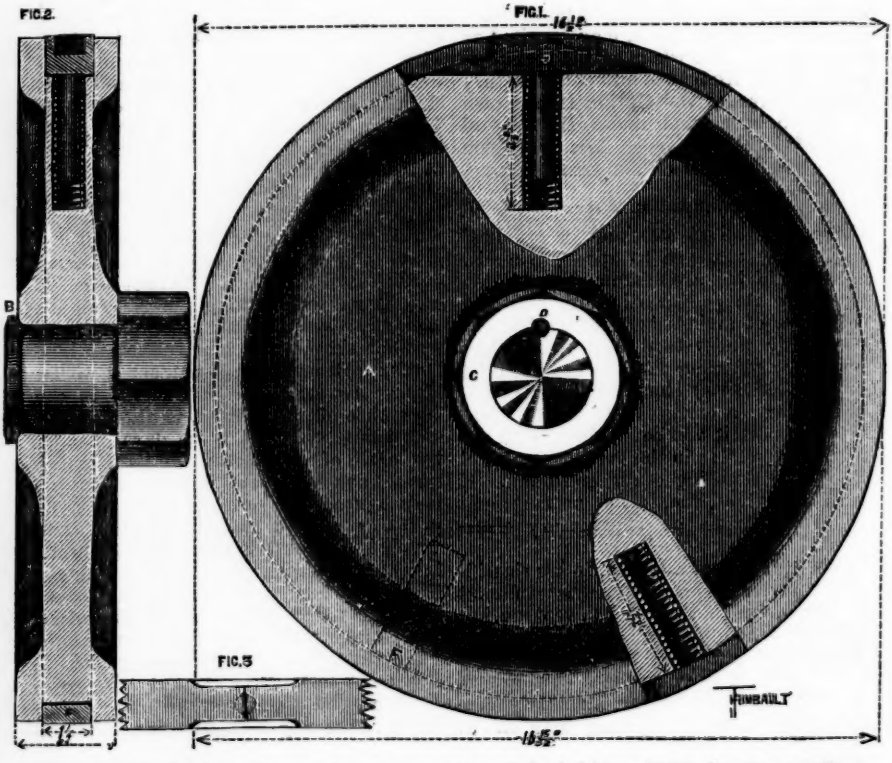
It is absolutely necessary to bear these leading principles in mind, before commenting at any length on the nature and meaning of engineering and the great works of the civil engineer. Of course I refer solely to the building part of engineering and not to mechanical work. As an example of my meaning, the new railway bridge at Hungerford will afford an apt illustration, and will be a guide to the consideration of other works. The bridge consists simply and constructively of that perhaps one solitary invention, as far as building goes, of modern times—the trellis girder, or constructive wrought-iron lintel, stretching from column to column over a wider space than would be possible otherwise. These support the rails and roadway, and are themselves borne up by the circular cast-iron cylinders or columns. These columns have no capitals further than the mere flange for the holding bolts at the top of the cylinders. There is no attempt by the engineer at ornament, or art, or architecture anywhere—it is all purely and solely constructive ; and it is a great pity that, by way of instructive example and guidance, it had not been left so. There was nothing unsightly in it ; it plainly revealed its purpose, and showed us what simple iron construction is like. But, unfortunately, the engineer of it, Mr. Hawkshaw, seems to have called in the assistance of an architect to glue on to it something which in these days goes by the name of architecture, and the consequence has been that this ingenious bridge is disfigured by a series of lumps of stone perfectly useless and unmeaning, and which have but the sole effect of dwarfing the iron-work and hiding its usefulness. These lumps are surmounted by a number of lamps which are never lighted, for the simple reason that they could throw light on nothing but the surrounding air! It is a most instructive example of how to spoil a good opportunity of doing something in the way of engineering architecture.

A great economy in the manufacture of bread, is secured by the following process: Gluten to the amount of 10 or 12 per cent. is extracted by boiling water from bran, and the flour is kneaded with this infusion, whereby from 20 to 30 per cent. more bread is obtained. The bread, of course, is not so white as that of first quality, but is much more nutritious.

LOCOMOTIVE PISTON.

From "The Engineer."

Accounts of novelties, though undoubtedly excellent things in their way, are sometimes of less value to an engineer than descriptions of arrangements or details which have been found by the test of lengthened practical experience to give thoroughly good results; and this being the case, we propose to give from time to time in this journal engravings illustrating the standard locomotive details which have been adopted by some of our chief railway companies. We thus give, herewith, engravings of the standard locomotive piston, designed by Mr. Samuel W. Johnson, the locomotive superintendent of the Great Eastern Railway—a piston,



we may add, which is of very simple construction, and which has been employed by Mr. Johnson for several years past with the most satisfactory results.

Referring to our illustrations, Fig. 1 is a front view, part in section; Fig. 2 is a section through the centre of the piston; Fig. 3 is a plan of the packing ring joint and tongue.

The piston, A, is made of cast-iron, the rim and boss being 2½ in. thick, and the rim or piston head being turned a full $\frac{1}{32}$ in. smaller than the diameter of the cylinder. The boss or centre is bored out conically, the taper being 1 in 23, and is exactly fitted on the piston rod, B, and secured by a brass nut, C. After the piston is fitted accurately on the end of the piston rod and the nut well tightened, a hole for a ½ in. tap pin is drilled in the end, one half in the nut and the other in the end of the piston rod. A wrought-

iron pin, D, is then tightly screwed into this hole, and the end is carefully riveted over. This pin prevents the nut from slacking back.

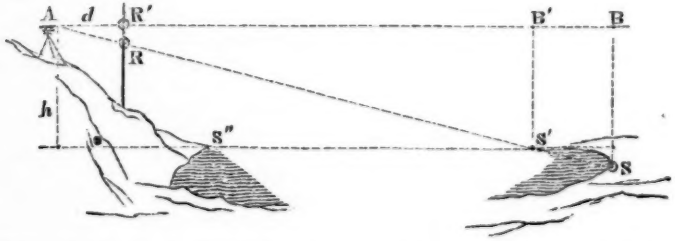
The packing ring, E, is also of cast-iron, $1\frac{1}{4}$ in. wide and $\frac{3}{8}$ in. thick. This ring is turned on the outside and edges only, and is made $\frac{1}{16}$ in. larger in diameter than the cylinder, being subsequently cut, as shown in Fig. 3, and $\frac{1}{8}$ in. taken out of it. It is then sprung into its place, and kept in its position by three spiral springs, F, two of these springs being placed near the bottom of the piston, and so compressed that they will just carry the weight of the piston and balance the thrust of the other spring, which is placed at the top of the piston directly under the brass tongue or stop piece, G, and the joint of the packing ring, so as to keep it bearing on the cylinder. All the springs are alike in strength, but it will be seen that the recess for the top spring is made $\frac{1}{8}$ in. deeper than the other two, so that the spring merely keeps the tongue and ring in contact with the cylinder. The piston, when finished, is found to move easily and fit accurately, and is comparatively light, the total weight, complete, of a $16\frac{1}{2}$ in. piston, including the brass nut, C, being 3 qrs. 14 lbs., and the total cost of the piston, finished complete, with packing ring, springs, tongue, brass nut, and tap pin, does not exceed 25s. The average mileage of one packing ring is from 25,000 to 30,000 miles, and the cost of the rings is but 9d. each.

MEASUREMENT OF DISTANCES BY THE LEVEL.

By W. L. MARCY.

To measure the contour of a lake with a level, ascertain by levelling the height of the level at A, above the water near the point of observation—denote it by h, also the distance AR′ of the level rod by d.

First level the instrument, and call



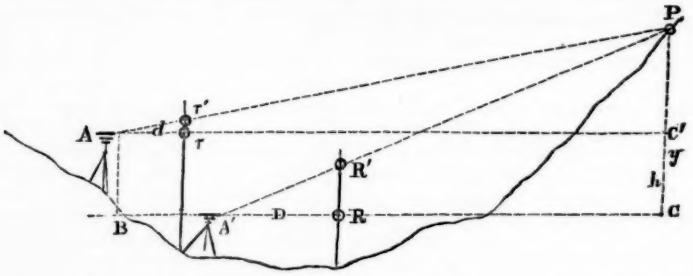
the reading of the rod R′; then depress with screws until the line of sight touches S, and call the reading of the rod R S″, S′ being the apparent level; it is obvious from simple proportion, that $A B' = \frac{h\,d}{R' - R}$, which answers for all purposes of plotting when the lake is small. Now h and d remaining constant, several points can be determined in a few minutes. To determine A B we can add $\frac{(A B)^2 \times .571}{R' - R}$ R′ A B being expressed in miles. For greater accuracy still, call A B x, which gives the quadratic

$$x = \frac{h\,d + x^2 .571}{R' - R}.$$

If the observations are made with a transit level they can be plotted by angle or course radiating from the points of observation to the different projections or indentations around the water; or if taken by a level only, the position of the rod may be taken by measurements, so that the whole can be easily plotted.

To measure distances with a level, both horizontal, vertical or inclined:

Let P be the point to be determined. A, A′ P and the rod being in the same plane. This plane can be determined by the eye—for the error is as the versin. of the variation from the plane—since the projections of B A′ or A r′, A′R′, are equal to those distances respectively, multiplied by the cosine of variation, which makes the error very small.



Beginning at A′ we take the reading R, then elevate the line of sight to P, taking the reading R′. Level back to A, proceeding as before. Denote A′R by D ; Ar, d ; AB, h c′c ; BA, h ; A′C by x and PC by y.

We may obtain by proportion the following equations for x and y :

$$y = \frac{R' - R}{D} \times x, \text{ and } y - h = \frac{r' - r}{d} \times (x + b),$$

which give $x = \frac{D\,b\,(r'-r) + h\,D\,d}{(R'-R)\,d - (r'-r)\,D}$, from which we we can readily find the vertical and inclined distances.

In running preliminary lines it is often desirable to find where your grade will strike on a distant hill, also what the grade is to a point required to be made in the survey. First, measure from the level toward the point to which you are running a given distance D, and take the level reading; then elevate the target D x grade, and the line of sight raised to the target will cut the hill above or below grade to the amount that the instrument is above or below the same. Denote the level reading by R, the upper or lower reading by R′; then $\frac{R'-R}{D}$ will be the grade to any point. When the lines deviate too much from an air line, the variation from these results in running will always be in excess both in ascending and descending, in consequence of lengthening the line. When the surface curves regularly, the increase in distance will be nearly as the versine of the deflection from the air line to the extreme points in the surface, right or left.

London Pavements.—"A Merciful Man," who signs "E. F. J.," writing from Paris to the "Times" of the 8th inst., extolled the excellence of the roads in Paris, and held them up as a model for London authorities. "It is perfectly true," says the Paris Correspondent of the "Times," "that the macadamization here is excellent, that the carriage ways where that system is adopted present a compact, well-bound surface, upon which the mud rarely becomes deep, and which is easily cleaned by the roller brush here in use. With respect to the other method of laying bitumen over lime and sand, it looks well and has advantages for pedestrians, but the horses and those who drive them do bitterly complain of and anathematize it. The sand sprinkling referred to by 'E. F. J.' is partial and ineffectual, and it is painful to see the horses struggling for foothold on the smooth surface, which, in certain states of the atmosphere, becomes greasy and almost as slippery as ice. So many are the complaints I hear of it that I am surprised still to see it being here and there laid down. It is all very well, however, to recommend London to improve its ways after the Paris model, but is London disposed to pay for such improvements? An army of men is here daily employed in taking care of the streets, roads, parks, and gardens of Paris, scraping, sweeping, rolling, watering, brushing up the mud with the roller above mentioned, strewing sand, and in other ways attending to the toilet of this luxurious city. Fancy stationing detachments of men with baskets of sand to diminish the slipperiness of the road!" Such a thing is a fact and not a fancy in one part of London, at least so we are informed by a correspondent. A sweep and a basket of sand are to be seen daily in that part of Threadneedle street recently paved with asphalte.

Some Northern capitalists have invested $1,500,000 in land along the Chesapeake and Ohio Railroad, Va., and purpose to build three or more large iron furnaces, one of which will be at Clifton Forge.

THE HEATON STEEL PROCESS.

MONSIEUR GRUNER'S REPORT.

(*Continued from page* 138.)

But the nitric acid is not the only thing reduced in the converter; a part of the soda is transformed into sodium at the moment when the alkali passes in thin streams through the bath of pig. The sulphuret of sodium and the sodium itself, which we find combined with the iron in refined metal, leave no manner of doubt on this point. But we have other proofs of it to advance. The jets of yellow flame which escape from the refined metal must be sodium vapors. The black smoke which issues from the converter when the flames go out must be chiefly sodium. I say chiefly, because the black smoke was not abundant in the case of the Longwy conversions, in which we proved that the soda partially disappears on account of the small quantity of silica in the slag. The black smoke of the Heaton converter is condensed vapor. It is a metallic dust just as ordinary smoke is carbon dust, and just as steam is a dust of liquid water. The smoke of the converter is necessarily complex. We ought to find in it volatile phosphoric compounds mixed with the sodium, and probably also, as in the Bessemer process, particles of iron and manganese. But this much is certain, that sodium is its chief constituent whenever the soda is not saturated with silica. This is precisely the distinction between the Longwy and the Hayanges conversions. In the latter case there was but little black smoke. The red vapors predominated, and calculation has shown us that in this case almost the whole of the soda was retained by the silica, while in treating less silicious brands a great deal of it disappears.

Let us remember, too, that, as in the Bessemer process, the heat developed during the reaction depends especially on the proportion of silicon contained in the pig. The charges of nitrate were the same in the first and fifth conversions—if anything the largest in the first. Well, the temperature was far higher in the fifth. The refined metal which was produced in this experiment was still semi-fluid at the end of an hour, while the product of the Longwy pig was solidified in less than a quarter of an hour. Now, the only difference between the two brands is, that one contains 3 per cent., and the other only 0.9 per cent. of silicon.

When lime is mixed with the nitrate, this also, like the soda, is partially reduced by the molten metal. This is proved by the experiment reported on by Dr. Miller, 14th October, 1868.

The products which he analyzed came from the conversion of a mixture in equal proportions of Clay-lane and Stanton No. 4 brands, both made from the oolitic ores of the upper lias.

The charge of molten metal was the same as in the preceding conversions, but the nitrate chamber was charged with 169 lbs. of nitrate, 40 lbs. of silicious sand, and 20 lbs. of air-slaked lime. The resulting slags were pasty, and unusually difficult to separate from the refined metal.

Dr. Miller's analysis gave the following results:

	Remelted Pig.	Refined Metal.
Carbon	0.02830	0.01800
Silicon	0.02950	0.00266
Phosphorus	0.01455	0.00298
Sulphur	0.00133	0.00018
Arsenic	0.00041	0.00039
Manganese	0.00318	0.00090
Calcium	0.00318	0.00319
Sodium	0.00318	0.00144

The refined metal consequently contains both sodium and calcium, only we must not forget that in the refined metal we always find a little slag, and that part of the calcium and sodium here ought to appear as silicates of lime and soda.

Dr. Miller did not analyze the cast-steel made from the cakes, but the samples were subjected to the tension test at Mr. Kirkaldy's, as the Moselle samples were.

Mr. Mallet gives, as the mean results of the testings which took place in August and September, 1868, the following figures: breaking strain per square inch of the original section, 41.73 tons, with an elongation of 7.20 per cent. Later experiments on steels made from various English brands gave the following results:

Description of Steel.	Breaking Strain.		Elongation per cent. of original length.
	Tons per square inch.	Kilos. per square millimetre	
Cast Steel :			
Dowlas No. 3, with 10 per cent. of nitrate.	42.2	66.00	1.4
Middlesbro', No. 4...	47.1	74.00	6.3
Glengarnock, No. 2..	41.1	65.00	6.3
Wokington hematite, with 7½ per cent. nitrate	48.4	76.00	2.7

We see, by comparing these figures with the table of the Swedish and Newberg steels, that the elongation is small as compared with the breaking strain, and that consequently all these steels, like those of the Moselle, are deficient in elasticity. We have still to examine from a chemical point of view the merchantable products of the refined metal, viz., malleable iron and steel. The malleable iron, as I have already said, is of little interest from a practical point of view, because the Heaton process is too costly for such a product. I have therefore contented myself with analyzing two samples.

Rolled Iron.—I analyzed the two bars, No. 1 and No. 2 of the first conversion, by the same process as the cakes, and operating on 10 grammes. Here are the results :

Elements.	Flat bar (Longwy No. 1) obtained without piling from conversion No. 1.	Flat bar (Longwy No. 1) piled from conversion No. 1.
Silicon.....	0.0023	0.0021
Phosphorus	0.0022	0.0016
Sulphur....	0.0002	0.0002 at outside.
Carbon.....	0.0006	9.0008

Comparing these figures with the analysis of the cakes of the first conversion, we see that the purification has progressed in every item but that of silicon. The phosphorus has been reduced from 0.0064 to 0.0022 and 0.0016, the sulphur from 0.0009 to 0.0002, the carbon from 0.012 to 0.0006 and 0.0008. The silicon, on the contrary, seems to have increased. But on this head we must observe that at least half the amount which figures here as silicon is due to the slag intermingled with the iron, so that in reality the fining has been progressive even here. Nevertheless, the iron is still impure; and moreover, as has been already said, it has been burnt by the workmen. It contains too little carbon with too much phosphorus, and this accounts for its small elongation before fracture. The piling, too, has produced very little effect either in point of chemical purity or elasticity. Dr. Miller analyzed the malleable iron prepared from the Claylane and Stanton brands, with the following results :—Sulphur traces : carbon, 0.00993 ; silicon, 0.00149 ; phosphorus, 0.00292. Sulphur traces: arsenic, 0.00024; manganese, 0.00088 ; calcium, 0.00318. Sodium traces.

The iron is not burnt; it seems, however carbonized ; but for that very reason the purification is less than with the Longwy iron ; the phosphorus has but little diminished.

Ingots of Steel.—In the analysis of the steel ingots I followed the same method as with the pigs, the irons, and the cakes, so as to obtain comparative results :

Elements looked for.	Ingot of Conversion No. 2.	Ingot of Conversion No. 3.	Ingot of Conversion No. 6.	Ingot of Conversion No. 8.
Silicon'.....	0.0014	0.0018	0.0021	0.0017
Phosphorus	0.0038	0.0025	0.0034	0.0050
Sulphur....	0.0003	0.0005	Trace.	0.0002
Carbon.....	0.0036	0 0055	0.0035	0.0062

Comparing the figures with the analysis of the cakes, we see at once that the purification has progressed, either by the atmosphere more or less, oxidizing of the crucibles, or by the addition of malleable iron and spiegeleisen. The percentage of phosphorus especially has diminished, though unequally. In the ingot of conversion No. 2, it has diminished from 0.0059 to 0.0038, while the silicon has remained stationary. In the ingot of conversion No. 6, the phosphorus is 0.0034 instead of 0.0078, and the silicon 0.0021 instead of 0.0045. This difference is greater on account of the dose of malleable iron having been increased in this instance. 14 lbs. of iron was used with 34 lbs. of cake, instead of 12 lbs. with 33 lbs. in the second operation. But this difference in the charge is not sufficient to account entirely for the diminution of phosphorus in No. 6. The evident anomaly is no doubt due to the want of homogeneity in the cakes. The anomaly is still greater in the case of the steels Nos. 2

and 3. The cakes of conversion No. 3 were obtained with less nitrate than those of No. 2, and yet we find in ingot No. 3 less phosphorus than in No. 2; on the other hand it contains, as we should expect, more silicon and carbon. At any rate we may deduce from these analyses that the ingots resulting from the white pigs, just as we proved in the case of the cakes, are better refined than those from the gray pigs. And this general result of the analysis is in accordance with the breaking strains, considered both with reference to the area of fracture and with reference to their elongation before fracture. When we compare, by the table of the breaking strains the steel of similar degrees of carburization resulting from different brands, we find that the steel of conversion No. 2, which is but little carburized, only elongates 12.5 per cent, while the bars of conversion No. 6, which, however, are double their dimensions, hardly elongate 1.3 per cent. And so the steel of conversion No. 8 elongates less than that of No. 3. To sum up, we see that the steel ingots prepared under the above conditions contain 0.0025 to 0.0038 of phosphorus and 0.0014 to 0.00018 of silicon when the Longwy white brands are converted, and 0.0034 to 0.0050 of phosphorus with 0.0017 to 0.0071 of silicon when the Hayanges gray pigs are treated.

We may add, too, that the purity of the tilted steel bars would be about the same; for simple reheating at a low red heat, followed by a rapid hammering, could hardly effect any perceptible change in this respect. The following table of their percentages of carbon, determined by the Eggertz method, suffices to prove it:—

	Carbon in the ingots.	Carbon in the tilted bars.
Steel of Conversion No. 2	0.0036	0.0033
" " No. 3	0.0053	0.0054
" " No. 5	0.0035	0.0032
" " No. 8	0.0062	0.0048

Hence it follows, definitively, as was also proved at Königshutte, that 0.003 to 0.005 of phosphorus does not prevent cast-steel or homogeneous iron from working well hot; but the metal, though its resistance under slow tension is often as high as that of good steel, really wants body. It is harsh, and has not the dynamic resistance of good steel.

Must we, then, conclude that the Heaton process is worthless, and that its adoption would offer no advantages? Such is not my conclusion. Doubtless we must not expect to obtain by this process first-class steel. Let us leave this specialty to the non-phosphoric ores, such as the spathic and the magnetic protoxides; but, on the other hand, let us not use these rare and expensive ores for rails. If we do so, what is to become of the common iron ores?

The nitrate process eliminates the phosphorus, at any rate partially, and better still, the silicon and the sulphur. The degree of purification depends on the proportion of nitrate. It is a question of cost. The question is, whether, in refining by this process white forge pigs produced from the common ores, we can obtain a metal of sufficient tenacity for rails and plate iron at a price less than the present price of Bessemer rails. The experiments cited do not enable us to give a categorical answer to the first question, viz., as to the working strength of the bars. Concussion tests should be taken instead of tension tests; or, better still, bending tests pushed to their elastic limits, similar to the tests reported in my work on steel. We should ascertain what percentage of phosphorus and silicon may be present without impairing the strength of the rail. Such experiments seem to me of importance, and I hope shortly to be able to enter upon them.

In the second place, it is necessary to show that the use of nitrate will not involve too great a cost. But first of all I must say how I understand the practical working of the Heaton process. The refined metal is not "steel," and still less "homogeneous iron." It is simply "purified pig," which ought to undergo a new treatment similar to the refining process of the Siemens-Martin furnace. Consequently it is to the pure brand, treated in the Martin furnace, that we should compare the Heaton refined metal. But we have seen that to refine pig iron by the new process we should have to go as far as charges of 10 to 15 per cent. of nitrate. That would be, at the present price of nitrate, a cost which would, for nitrate alone, reach 32s. to 48s. per ton of refined metal, and in any case 20s. to 30s. if we assume that the price of nitrate will come down from £16 to £12 per ton, which seems quite possible by better organization of the mining industry, and of the

means of transport from the mines to the coast of the Pacific; and here we should note, that the feasibility of the practical adoption of the Heaton process depends to a great extent on the price of nitrate. This price was about £12 per ton before the Peruvian earthquake of last year. It was raised to £16 in consequence of that disaster. The deposits of nitrate in Peru and the north of Chili are very extensive, and to a great extent still undeveloped. An increased consumption, instead of raising the price, would probably lower it by causing the working of new mines and the construction of cheap railroads from the nitrate district to the coast. However, even at a price of £10 or £12 per ton, the cost would still be high if the phosphorus and silicon were to be oxidized exclusively by nitrate. But we can do better than this.

I have already said that the common refining and puddling process easily eliminate the greater portion of the silicon and phosphorus in the presence of the basic slags. Between these two methods, moreover, we need not hesitate. The finery process is preferable in point of cost, and it can be carried out either on the "low hearth," or in the reverberatory furnace, only in either case we must have furnaces with chilled metal lining and strongly basic slags. We may then have recourse to the English finery and use coke as pure as possible, and render the slags extra basic by repeated additions of rich and purer ores of iron and manganese. Or, if we fear contact with sulphurous and reducing fuel, we can use a reverberatory furnace with an air-current or blast heated by coal or gas on the Siemens or any other plan.* But in any event the *sine qua non* of success is to have the furnace lining of properly chilled cast-iron like the boiling puddling furnaces, and to fettle the interior with roasted scrap or rich oxide of iron. We have already seen, by the example of M. Eck's furnace at Königshutte, what is the result of refining on a sand hearth. The phosphorus becomes concentrated in the refined metal, because the slags become silicious. This is equally the case with the Martin furnace, the heart of which is sand. The phosphorus cannot be removed on account of the silicious character of the slags, and we cannot in this case render them basic without destroying the furnace. The sand and the bricks are quickly melted down by the oxide of iron. But what cannot be done in an ordinary reverberatory furnace succeeds perfectly in a furnace lined with chilled cast-iron, arranged like *a boiling furnace*. The pig would be there melted—or, rather, it would be run in from the blast furnaces in a molten state. It would then be refined between a hearth of oxide of iron and a layer of ferruginous slags, maintained in a basic condition by repeated additions of rich ore, and, if need be, as in the Eck furnace, by the aid of plunging tuyeres and a blast. The operation would be stopped short of decarburization; then, to finish the purification, the refined metal would be run direct into the Heaton converter, where a small charge of nitrate would easily eliminate almost the whole of the silicon and the remaining phosphorus and sulphur. Thence the refined metal would pass into the Martin furnace, where its conversion into steel or homogeneous iron by reaction would be finally completed.

I cannot refrain from taking this opportunity of observing that the common Martin process should be modified in the same way. What is the fault of the Martin process? It is its extreme slowness if the pigs are at all silicious. It produces steel by *reaction*—that is to say, by simply mixing malleable iron and pig iron, but if the pig contains silicon how is it to be got rid of except by oxidation? and how oxidize it without destroying the lining of the furnace by the added oxides? When the pigs are silicious, the plan adopted is that of prolonged fusion to oxidize the silicon by the action of air. Instead of heating the pig in an ordinary reverberatory furnace and then remelting it in the Martin furnace, it would certainly be better to refine it first of all in a *boiling* furnace (*four bouillant*) and thence to run it direct into the Martin furnace to be mixed with the malleable iron.

But let us return to the Heaton process for the treatment of the common brands. These are the modifications the adoption of which, in my opinion, would permit its practical application to the production of rail metal from such brands.

(1.) The molten metal should be run direct from the blast furnace into the

*Mr. Samuelson's new furnace, with a pivoting hearth, above mentioned, would answer the purpose.

finery furnace, as is done in several Welsh works, or, better still, into a *boiling* furnace to be refined by blast and oxide of iron.

(2.) Thence the refined metal should be run into the Heaton converter to be treated with nitrate. (We know that in some works in Wales the refined metal is run direct, to be refined with charcoal, into a low Comtois hearth.)

(3.) Then the metal, twice refined, should be passed at once, whether fluid or solidified, into the Martin-Siemens furnace, to be converted into soft cast-steel or homogeneous iron by being mixed with malleable iron or spiegeleisen. Let us add that if we carried the refinery in the converter as far as true decarburization, the refined metal could be charged into the Martin furnace instead of malleable iron. That depends on the degree of purification attained. We see that by this mode of treatment we should adopt that valuable principle of progressive refining which I long ago recommended in my work on steel (p. 106) for the treatment of the common brands.

It is unnecessary to add that if the pig only contained one per cent. of silicon and one-quarter to one-third per cent. of phosphorus, we might dispense with the first finery and run the metal direct from the blast furnace into the Heaton converter. We have still to prove that the cost of this double finery would not be disproportionate to the value of the product we should expect to obtain.

The average waste of the finery is from 8 per cent. to 10 per cent.; but this waste would be reduced if we added rich ore to the molten metal. I will assume it to be reduced to 5 per cent. On the other hand, the average consumption of coke in England is from 200 to 250 kilos., say 440 lbs. to 550 lbs., per ton of refined metal, when the molten metal comes direct from the blast furnace, and would be 400 kilos., say about 8 cwt., of coal if we were to work in the same way in the reverberatory furnace. The cost of manual labor and incidental charges vary, as we know, from 2s. 6d. to 3s. 4d. per ton. Taking, then, the actual price of the Moselle forge pigs, we should have for every ton of refined metal: 1 ton of forge pig at 63f. (£2 10s.), 5 cwt. of coke at 7½f. (6s.), labor and incidental expenses 4f. (3s. 4d.). Total, 74f. 50c. (£2 19s. 4d.). In the reverberatory furnace we should have 400 kilos. (say 8 cwt.) of coal at 12f. or 10s., say 4f. 80c. instead of 7f. 50c., or 4s. instead of 6s., which would reduce the price of the refined metal to about 72f., say £2 17s. 4d. This is the cost we will assume, because refining in the reverberatory furnace is always more effectual than fining on the hearth. The pig so refined would waste but very little in the converter, because the silicon and phosphorus would be to a great extent eliminated. We may take 5 per cent. as a maximum. If, on the other hand, we assume that we have to oxidize 0.003 to 0.004 of silicon, and as much phosphorus and sulphur, and about 1 per cent. of carbon, we should need 20 kilos. to 22 kilos., say 44 lbs. to 48 lbs., of oxygen, which would take 1 cwt. of nitrate. The cost would then be: For 1 ton of refined metal at 75f. 60c. (£3 9s.); 1 cwt. of nitrate at 400f. or £16 per ton, 20 f. (16s.); labor and wear and tear, etc., 4f. (3s. 4d.). Total, 99f. 60c. (£3 19s. 4d.). With the expenses of management and royalties we should so arrive at a maximum cost of 110f. per 1,000 kilos.—a figure which would be reduced to 100f., or £4, if the price of nitrate were to be reduced, as is probable, or if cheaper chemicals were to be partially substituted for the nitrate. Now, we know that the average price in France of brands suitable for the Bessemer and Martin processes is 115f. to 120f. There would, therefore, be a certain amount of profit in using nitrate (even at £16 per ton) for the purification of common brands. It remains to be proved by new experiments if rails so made would possess, as I believe they would, sufficient elasticity.* (*Resistance vive.*)

I have just said that the cost of the refined metal might be lowered if we were to substitute cheaper chemicals for some portion of the nitrate. Let us go into some details on this question.

In the first place, we might, to some extent, substitute carbonate of soda for the nitrate. This salt has an oxidizing effect by its carbonic acid, which is reduced to carbonic oxide. Its available oxygen is 15 per cent., instead of 44 per cent.; but the proportion of base which would take up the acid is 58 per

* The experiments on the "dynamic resistance" of Heaton steel, published by Sir Wm. Fairbairn after Mr. Grüner's work was in type, appear to establish this point conclusively in its favor.

cent. instead of 34 per cent. From this point of view there would be something to be gained by mixing these two salts. The experiment was tried on my suggestion at La Villette. Instead of 10 per cent. of nitrate, 9, 8, and 7 per cent. were used successively with 1, 2, and 3 per cent. of carbonate. The phenomena of conversion were the same, but the reactions were less violent, and the metal also seemed less modified. The analysis of the products is not yet finished. I cannot, therefore, be positive as to the results.

Again, to augment the percentage of oxygen while reducing the cost, I caused peroxide of manganese to be mixed with simple nitrate, and with nitrate and carbonate. This oxidizing reagent had also been tried by Mr. Heaton at Langley Mill. It was given up because the temperature developed is not always high enough to melt the protoxide, in which case the product is a pasty mass and the slag not homogeneous. The oxygen liberated is, in fact, 18 per cent. at best; sometimes only 12 or 15 per cent. In spite of that the conversion is quite as successful when we content ourselves by substituting an equal weight of peroxide for about one-third or one-fourth of the charge of nitrate. But we must take care that the mineral be pounded fine, and thoroughly mixed with the nitrate, or carbonate and nitrate.

Mr. Heaton at first used a mixture of nitrate and slaked lime. This was done in July, 1868, when Dr. Miller and Mr. Mallet went to Langley Mill to investigate the new process. The lime acts as a strong base, but renders the slag more pasty. That is a disadvantage. If we wish to arrive at running the metal direct into a Siemens furnace we must have fluid silicates, so that the metal may disengage itself from the slag. This end is attained by substituting fluor spar for lime, as Mr. Heaton has himself lately proved at Langley Mill. My only fear is that some little sulphur might be introduced into the metal with the fluor spar, which almost always contains sulphate of barytes.

We can render the slags perfectly fluid without running the same risk by mixing common sea salt with the nitrate. The experiments I have just had tried at La Villette prove the efficiency of chloride of sodium. With mixtures of 7 per cent. of nitrate and 1 to 2 per cent. of sea salt, the slags become as liquid as water. The phenomena of conversion are just the same as usual, except that there is an abundant liberation of suffocating vapors. The sea salt is volatilized with other chlorides; but these chlorides probably themselves effect some purification of the refined metal. That is a matter still under examination. In any case, 1 to 2 per cent. of sea salt will always be very useful to increase the fluidity of the slags of the converter.

In fine, we see that there are still questions for examination, and that it may be advantageous to add other reagents either as fluxes or oxidizers to the nitrate.

I have but one other point to speak of, viz., the arrangement of the apparatus. The converter is very simple. The molten metal can be easily run into it, either by a trough, or by a crane ladle, or by a wagon running on trams. The most troublesome part of it—at any rate, when converting on a large scale—is the manual labor, and the fixing of the nitrate chamber. But a little tramway passing under the converter would allow of its being run into its place, and, instead of attaching the chamber to the converter by clamps, one might use a hydraulic lift, which would hold it tightly in its place during the conversion. After the conversion the nitrate chamber, with its contents of refined metal, would be removed in the same way to the Siemens furnace, where the treatment for steel would be finished.

Having now arrived at the end of my long memoir, I think I should sum up the principal results.

Conclusions:—The Heaton process could never, *from any point of view*, be a substitute for the Bessemer and Martin processes. These produce ingots of steel or homogeneous iron from pure brands. The Heaton process deals with impure brands, and seeks to convert them into a refined metal more or less purified, the treatment of which has to be finished in a Siemens furnace. Its aim is to preserve for the common ores the place which the pure ores have for some time tended to usurp—iron and steel for springs, tires, and large guns.

Plates should be left to the pure ores; rails and bars of homogeneous iron,

more or less hard, to the common ores.

The purification is based on the reaction of Peruvian nitrate of soda. The apparatus is simple, ingenious, and very cheap. The operation is rapid, easy to manage, and not liable to explosions.

The nitrate refinery acts like the ordinary methods based on the employment of air or the metallic oxides. The silicon and manganese are first oxidized, the phosphorus and sulphur are eliminated next, the carbon last.

The degree of purification depends, of course, on the proportion of nitrate; but we should hardly be able to achieve an absolute purification even with 12 to 15 per cent. of nitrate.

To reduce the cost we must use brands which contain little silicon, and generally use refined pig rather than crude pig.

The greater part of the silicon and phosphorus ought to be eliminated by a preliminary refining. This ought to be done on the low hearth, or, better still, in a reverberatory furnace; in any case, in a furnace with a lining of properly chilled cast-iron, and with the aid of roasted scrap (*riblons*) or natural oxides of iron, so as to leave the molten metal always exposed to the action of strongly basic slags. Even the pure silicious brands which are meant to be made into cast-steel by the Siemens-Martin process ought to be treated to a preliminary refining.

The Moselle brands were converted at Langley Mill without any such preliminary refining, and with an insufficient dose of nitrate. The result was a refined metal retaining still, in the most favorable case, as much as 0.005 of phosphorus, 0.0014 of silicon, and 0.012 of carbon. This metal was converted partly into malleable iron by a quick puddling, partly into cast-steel by reaction in crucibles. Neither of these methods is economical. The only advantageous method is the conversion of the metal in a Siemens furnace into homogeneons iron or soft steel by the Martin process.

The cast-steel made in the crucible from the insufficiently refined Moselle crude steel still retains 0.002 to 0.004 of phosphorus, 0.0014 to 0.0018 of silicon, 0.003 to 0.004 of carbon, and traces of sulphur. In spite of this the steel works well hot, and gives good results when tested by slow tension; but its elongation is small, and this would seem to indicate a want of elasticity. (*Resistance vive*).

If the process were modified as I have suggested, the results would probably be different. At any rate, further experiments are requisite before we can definitively pronounce upon the elasticity* of the bars prepared by this process; and, on the other hand, it is certain that the Heaton process, properly carried out, would seem to realize the purification of common brands better than any other known method. We are not, however, as yet in a position to affirm that the purification is as complete as we could wish.

SAFETY EXPLOSIVE COMPOUND.—Mr. Percy A. Blake, of Aberdeen Park, Highbury, has patented an explosive compound, the constituents of which are simply sulphur and chlorate of potash, in the proportions of about one of sulphur to two of chlorate of potash. These substances can be kept separately in a dry powdered state, and mixed by sifting, when required. This mixture has been known for years to detonate when struck with a hammer, but was useless as an explosive agent, because it merely burnt slowly when fired by the ordinary fuses. The invention, therefore, consists in rendering this compound practically to explode by the use of a peculiar kind of detonating tube or percussion cap, which renders it exceedingly serviceable for torpedoes, blasting, shells, blowing down palisades, and other similar appliances. The detonating tube to be employed is made of metal, about an inch in length, and about $\frac{7}{32}$ of an inch in diameter, the bore being about $\frac{2}{32}$; but the inventor does not confine himself exactly to these dimensions, as a larger or smaller tube can be used for the purpose. First is introduced into it some of the compound, and well pressed down; next, some fulminating mercury, and then a small quantity of detonating silver, and the rest of the tube may be filled up with meal powder. The end of the tube, which is filled with the compound, is to be placed in contact with the compound contained in the vessel to be fired, and the other end may be fired by any kind of ignition apparatus.

*Sir William Fairbairn's experiments.

LONG AND SHORT PILLARS.

From "The Building News."

It is always a difficult task to define a limit, and to draw the exact line of demarcation between the application of one law and that of another. Occasionally instances occur where one or other of two laws apply with equal fidelity, but these are rare. The subject of our article furnishes a remarkable instance of the ambiguity attending certain descriptions of design. Although we have the elaborate and accurate series of experiments conducted by the late Mr. Hodgkinson to guide us, as well as the rules and formulæ deduced by him to form the basis of our calculations, nevertheless, it is by no means certain what constitutes a long, and what a short, pillar. When extreme cases are taken, there is no difficulty, but it is when the proportion of the length of the column to its diameter is such as to bring it near the boundary that marks the distinction, that uncertainty prevails. Assuming that a long pillar is one in which the ratio of length to diameter, or to the least lateral dimension, is not less than 30, it is evident that a column in which that proportion was 28 or 29 would very nearly be a long column, and must, therefore, present some different features to one in which the ratio is represented by 10 or 12. At the same time there must be some line between the two descriptions of columns, as a pillar obviously cannot belong to both classes. In the category of long and short pillars, the minimum ratio of height to diameter is as 5.5 to 1. When this ratio is still further reduced, so that the proportions become reversed, the specimen is no longer, strictly speaking, a pillar, but a disc. Any of the current coins of the realm are examples of our meaning. Discs will bear an enormous pressure before they become what is technically termed "upset." The crushing or splintering strain, even in the same material, does not appear to be governed by any accurately defined laws. The probability is that the particles of the disc situated nearer to the centre, or axis, are prevented from moving by the confining resistance of those nearer the circumference. It is not difficult to imagine this resistance to pressure in some specimens augmented in this manner almost *ad infinitum*. The compressive strength of a disc being thus so greatly in excess of any requirement that might be demanded of it, any calculation respecting its resistance may be fairly considered superfluous. We confess we should have thought so, but the experience so dearly bought by the Holborn Viaduct proves the contrary. The marble bases, that now, cracked and seamed, bear testimony to the manner in which the public money is squandered through recklessness and incompetency, are not pillars but discs, insomuch as their diameter considerably exceeds their height. Taking $2\frac{1}{2}$ tons, in round numbers, for the crushing strength of marble per square inch of superficial area, it is not easy to understand the splintering of the specimens in question.

From discs we pass to very short pillars in which the length does not exceed 5 or, at the maximum, 6 times the diameter. It was from examples of this kind that the crushing strength of iron and other materials was determined, and their resistance is proportional to their sectional area. Consequently if D be the diameter of one of these pillars and C the crushing strain of the material, then, putting the breaking weight equal to W, its value is given by the equation W

$$W = \frac{\pi \times D^2}{4 \times C}.$$

As an example, let us take the crushing strain of cast-iron to be equal to 40 tons, and the pillar to be solid, and having a diameter of 9 ins. What is its crushing weight in tons? Substituting these values in the equation, we have

$$W = \frac{\pi \times 9 \times 9}{4 \times 40} = 63.6 \times 40 = 2544 \text{ tons.}$$

Allowing one-sixth of this as the safe working load, the pillar may be loaded with 427 tons. The subject of the ratio between the breaking and safe working load, will be referred to in another portion of our article.

There are two other descriptions of pillars requiring consideration, namely, those where the length exceeds 30 times the diameter, and those where the proportion is under that number. The

former of these are known as long pillars, and their strength has been determined by actual experiments, from which rules have been deduced for calculation. As long columns are never cast solid, our investigation may be limited to a consideration of hollow ones. If D and D_1 be respectively the external and internal diameter of a hollow cast-iron column, L the length, and C a constant, the breaking weight W will be represented by the formula

$$W = \frac{C \times (D^{3.5} - D_1^{3.5})}{L^{1.63}}.$$

A little reflection will at once point out that this formula consists of two parts, the theoretical and the experimental or empirical. It was long since demonstrated by Euler, who in his time was the ablest mathematical analyst in all Europe, that the strength of long pillars was in direct proportion to the fourth power of the diameter, and inversely as the second power or square of the length—that is, as $\frac{D^4}{L^2}$. Had the material been wholly incompressible, and the conditions assumed in Euler's theory reducible to practice, the experiments undertaken might have corroborated his statement. But as theory never can be absolutely carried out in practice, the results, to some extent, do not agree. Instead of D^4 they gave a fractional index equal to 3.5. The determination of the constant multiplier C was arrived at by making experiments upon 13 different descriptions of irons, and the mean value was 42.34. A value was also determined for the power of L, which differed from that laid down by Euler. It should be mentioned here that some of the theories of Euler must be received with caution. Euler was, in his day, the most able and distinguished mathematical analyst in all Europe, but he sometimes wrenched data and premises to suit his purpose. Speaking technically, he did not care much about the solidity and stability of his foundation, provided only he was able to erect an elegant and beautiful superstructure. Many of his conclusions redound more to his credit as a subtle algebraist and analyst than to his honor and integrity as a votary of science. Some few of his theories have been altogether exploded by the results of subsequent experiments.

Combining the information derived both from theory and experiment, and substituting for C the value given above, the breaking weight W of a long hollow cast-iron pillar will be given by the equation

$$W = \frac{42.34 (D^{3.5} - D_1^{3.5})}{L^{1.63}}.$$

The powers of D, D_1 and L may either be obtained from tables compiled for the purpose, or calculated in the usual manner by logarithms. There will be no difficulty in our young professional and amateur readers accomplishing the calculation, if they keep before them the general axiom that the logarithm of a^n is always equal n times logarithm of a. Or, supposing a to represent any number, and n any index or power, then log. $a^n = n$ log. a. This is the fundamental equation for all logarithmic calculations, and should be committed to memory by the student. Manifestly there is yet the third class of columns to be investigated, which occupy an intermediate position between the very short and the long columns. They may with propriety be called medium pillars, and their strength will evidently be greater than that of long pillars, and less than that of those which are so short as not to deflect before fracture. These pillars break by the combined action of crushing and bending, and it is impossible to state the exact proportions in which these two agents act in determining the final breaking of a column. But although their exact relative influences cannot strictly be arrived at, yet an approximation sufficient for all practical purposes may be obtained. Thus it is supposed that the pillar has two duties to perform—one to support the weight, and the other to resist the bending action, and that half its strength is employed against the former of these forces, and the other half against the latter. If we put W to equal the breaking weight of one of these medium pillars and employing the same notation as that used previously, we have

$$W^1 = \frac{4 W C}{4 W 3 C}$$

In this equation W is the breaking weight of the pillar calculated by the former formula on the supposition that it was a long pillar, and would yield by flexure. Respecting the working load that may safely be put upon cast-iron columns, nearly the same diversity of

opinion exists as in the analogous case of girders and bridges. The nature of the load must always be taken into account, as it exerts quite as much, and perhaps a greater, influence upon the column than its absolute weight. If the column be in a situation where it is certain to be free from vibration, under all possible circumstances, it may be safely loaded with a fifth of its breaking load. Cast-iron pillars are now very much employed in supporting the floors of factories and warehouses, where a good deal of loading and unloading of goods and heavy merchandise is continually going on. In these situations the safe proportion should not be greater than one-sixth. The most trying position for cast-iron columns is where they form portions of cranes and gantries, and are subjected to violent jerks and shakes. Under these severe and exceptional circumstances, the working load should not exceed one-tenth of the actual breaking weight. It may be noticed in conclusion, that short pillars may be loaded proportionally heavier than long ones, since the smaller the casting the better the chance of obtaining them sound and trustworthy. The recent accident at King's College shows the danger of employing unsound and defective castings, especially of large size.

THE COST OF STEAM POWER.

From "Engineering."

Although in the vast majority of cases where steam power is employed, it is an object to obtain it at the least possible cost, yet we but comparatively rarely find an instance in which more economical results could not have been obtained by the exercise of competent judgment in the choice of an engine and its accessories in the first place. This may appear to be a somewhat broad assertion; but it is, nevertheless, one amply justified by facts which are open to the consideration of all who choose to seek for them. In most of our more important water-works, at many of our mines in Cornish districts, and at a small number of our larger factories, where the whole of the arrangements have been left to a competent engineer, may be found steam power supplied at an economical rate; but these instances are exceptional, and form but a very small percentage of the whole number of cases in which such power is employed.

The fact is that but very few users of steam power recognize the numerous items of which the cost of such power is made up; while a still smaller number give any consideration to the relations which these items bear to each other, or to the manner in which the economy of any given engine is effected by the circumstances under which it is worked. Very many people—and people who ought to know better too—imagine that an engine which is good for one situation is good for all, whereas a greater error than such an assumption can scarcely be imagined. It is true that there are certain classes of engine which may be relied upon to give moderately good results in almost any situation; but where the *best* results are desired—and the best results always *should* be desired in planning a factory—there are a considerable number of details which must be taken into consideration in making a choice of an engine. To the principal of these considerations we now propose to direct attention, premising that our remarks are intended to apply to the choice of engines for what may be called permanent use, as, for instance, at a mill or factory. The case of engines intended for temporary employment only, is an entirely different one, and we may perhaps have something to say about it on a future occasion. We shall also suppose for the purpose of simplifying the matter as much as possible, that it has been determined that the work of the mill or factory for which the motive power has to be chosen can be best performed by a single engine. The question of how far it is advisable to divide the total power required amongst a number of engines, for the purpose of saving shafting and for general convenience, is of itself a most important one, and demands independent consideration.

The expenses which go to make up the cost of steam power may be divided into six items, each to a certain extent dependent upon, and each, also, to a certain extent independent of, the others. Thus we

have, firstly, the interest upon the cost of the engine, boiler, engine and boiler houses, and accessories; secondly, the charges for repairs and depreciation; thirdly, the cost of attendance; fourthly, the cost for lubricating materials and miscellaneous stores; fifthly, the cost for water; and sixthly, the cost of fuel. Now in choosing an engine for the performance of any given work all these independent items should be carefully considered, and the object sought should be to make their sum total as small as possible, due regard being of course paid to the nature of the work to be performed.

The first item we have mentioned, namely, the interest on the first cost of the engine and accessories, may itself be subdivided with advantage into the amounts of interest on the respective costs of, firstly, the engine and boiler houses; secondly, the foundations for the engine; thirdly, the engine; and fourthly, the boilers. In some cases—as for instance the pumping stations connected with the Metropolitan main drainage, and other works of a national or exceptionally important character—it is not only justifiable, but praiseworthy, to sacrifice a certain amount of first cost for the sake of obtaining a good architectural effect in the buildings containing the engines and boilers; but inasmuch as we consider that the interest on the extra outlay thus involved is not fairly chargeable to the cost of the steam power, we shall say nothing further about it here, and shall consider engine and boiler houses merely as affected by the class of engines and boilers they have to contain. Here, then, we come to the first point in our choice, namely, the *form* of engine to be adopted. In some few cases—as for instance where engines have to be placed in confined situations—the form is practically fixed by the space available, it being perhaps only possible to erect a vertical or a horizontal engine, as the case may be. These, however, are exceptional instances, and in most cases—where large powers are required at all events—the engineer may have a free choice in the matter. Under these circumstances the best form, in the vast majority of cases where machinery has to be driven, is undoubtedly the horizontal engine, and the worst the beam engine. Properly constructed, the horizontal engine is equally durable with the beam engine, while its first cost is much less; it can be driven at a higher speed, and it involves a much smaller outlay for engine house and foundations than the latter. In many respects the horizontal engine is undoubtedly closely run by the best forms of vertical engines; but, on the whole, we consider that where machinery is to be driven, the balance of advantages is decidedly in favor of the former class, and particularly so in the case of large powers.

The next point to be decided is, whether a condensing or a non-condensing engine is to be employed, and if the former, whether an ordinary injection or a surface condenser should be used. In settling these questions, not only must the respective first costs of the two classes of engine be taken into consideration, but also the costs of water and of fuel. Excepting, perhaps, in the case of very small powers, and in those instances where the exhaust steam from a non-condensing engine can be turned to good account for heating purposes, it may safely be asserted that in all instances where a sufficient supply of condensing water is available at a moderate cost, the extra economy of a well-constructed condensing engine will fully warrant the additional outlay involved in its purchase. By employing steam of a very high pressure, a well-constructed non-condensing engine can, no doubt, be made to approximate closely to the economy of a condensing engine supplied with steam at the pressures usually adopted in mills; but in this case the extra cost of the stronger boilers required will go far to balance the additional cost of the condensing engine. It may, however, happen that there is a scarcity of water for condensing purposes, and that if a condensing engine is employed, either an extra supply of water will have to be paid for, or cooling ponds provided. Of course, if this is the case, these matters must all be taken into consideration in making the choice.

Again, it may happen that, although there is a plentiful supply of water of some kind, there is a scarcity of water suitable for feeding boilers; and it is in a case like this that a surface condenser is especially applicable; while in some cases, where there is a scarcity of water of all kinds, an air-surface condenser will do good service and effect an important economy.

Supposing now the form of engine to

be fixed upon, it remains to be decided what "class" of engine shall be adopted; and by the term "class" we here mean the relative excellence of the engine as a power-producing machine. Of course an engine with steam-jacketed cylinder, expansion gear, etc., costs more than a lower class of engine without such apparatus, and it depends upon the cost of fuel at the place where the engine is to be worked, and the number of hours per day it is kept running, which class of machine can be adopted with the greatest economy to the proprietor. So long as a certain form of engine is adhered to, the cost of foundations, engine-house, and general accessories, will be the same whether the engine is of a high or low class, while the cost of attendance will also be practically the same. The cost of lubricating materials, fuel, repairs, and percentage of cost to be put aside for depreciation, will all be less in case of the high-class than in that of the low-class engine, while the former will also require less boiler power. Against these advantages are to be set the greater first cost of the high-class engine, and the consequent annual charge due to capital sunk. These several items should all be fairly estimated when an engine is to be bought, and the class chosen accordingly. Let us take the item of fuel, for instance, and let us suppose this fuel to cost 10s. per ton at the place where the engine is to be worked, this price including the cost of stoking. If, now, the engine is run the usual number of hours per week, it will, as we have already stated, consume about 1½ tons, or 15s. worth, of coal per horse power per annum for each pound of coal per horse per hour. To be really economical, therefore, any improvement which would effect a saving of 1 lb. of coal per horse power per hour must not cost a greater sum per horse power than that on which the 15s. saved would pay a fair interest. Supposing, for instance, that a mill proprietor estimates his capital as worth to him 10 per cent. per annum, then the improvement which would effect the above-mentioned saving must not cost more than £7 10s. per indicated horse power, and so on. If, instead of being run the usual number of hours per week, the engine is run night and day, then the outlay which it would be justifiable to make to effect a certain saving per hour would be doubled, for the annual total saving would also be doubled; while, on the other hand, if an engine is run less than the usual time per week, a given saving per hour would justify a corresponding less outlay.

It is for reasons such as we first pointed out that it is impossible, without considerable investigation, to say what is really the most economical engine to adopt in any particular case; and as comparatively few users of steam power care to make this investigation, a vast amount of wasteful expenditure results. Although, however, no absolute rule can be given, we may state that the number of instances in which an engine which is wasteful of fuel can be used profitably is exceedingly small. As a rule, in fact, it may generally be assumed that an engine employed for driving a mill or factory cannot be of too high a class, the saving effected by the economical working of such engines in the vast majority of cases enormously outweighing the interest on their extra first cost. So few people appear to have a clear idea of the vast importance of economy of fuel in mills and factories that we perhaps cannot better conclude this notice than by giving an example showing the saving to be effected in a large establishment by an economical engine.

Let us take, for instance, the case of a mill having engines which require 35 lbs. of water to be converted into steam per indicated horse power per hour; this being a moderate amount as things go and requiring a so-called "good" engine. If now the engines in this mill indicate 300-horse power and work 24 hours per day for 300 days in the year (and there are many mills where the engines do this), they will require 75,600,000 lbs. of feed water evaporated per annum; and to do this in London, or districts where coal is equally dear, would cost about £4,000 annually. If now, in place of the engines we have supposed above, the mill was fitted with others, of a high class, such as that we illustrate on page 5 of the present number, the quantity of water which would be necessary to evaporate would not exceed 22½ lbs. per indicated horse power per hour, and the total annual quantity would thus be reduced to 48,600,000 lbs. To evaporate this quantity under the same circumstances as we have before supposed would cost but £2,570 per annum, and there would thus be an annual saving of

£1,430 available for interest on the extra first cost of the better engines. But, as we have already stated, the cost of foundations, engine-house, and accessories, would be the same for the high class as the lower class engine, while the former would require less boiler power, there being less water to evaporate, so that the difference in the first outlay would really be rather less than the mere difference of cost of the two engines themselves. For this difference of cost in the case of engines of 300 indicated horse power, £1,430 would certainly be an ample allowance, and the difference would therefore, in the case we have supposed, be paid off in a single year by the saving of fuel effected by the better engines.

Supposing, now, that after the first year the annual saving of £1,430 is invested every year at 5 per cent. compound interest, then the mill-owner will be richer at the end of ten years by £15,767, at the of twenty years by £43,672, and at the end of thirty years by £82,120, than he would have been if he had gone on using the engines requiring 35 lbs. of steam per indicated horse power per hour. In other words, he would simply, by sinking £1,430 for one year, have accumulated, during the succeeding thirty years, nearly *ninety thousand pounds;* and not only this, but he would, during that time, have had his mill driven by engines which would be more cheaply kept in repair, and be less liable to give him trouble by break-downs, than those of an inferior class. We have, in the above comparison, supposed the less economical engines to use 35 lbs. of steam per indicated horse power per hour, but this is a very moderate allowance for ordinary mill engines, and the majority of such engines use from 45 lbs. to 50 lbs. of steam per indicated horse power per hour. In such instances the saving we have shown to be effected in the economical engine would be doubled, while in the case of such engines as that at the Ryesholm pit, Ayrshire, on which Professor Rankine made the experiments described on page 300 of our last volume—an engine which, even after being fitted with a Morton's ejector condenser, used 55.2 lbs. of steam per indicated horse power per hour—the saving would amount to three times as much as we have assumed in the foregoing calculations, or £4,290 per annum. Invested at 5 per cent. compound interest, as before, this annual saving would amount in 10 years to £47,301, in 20 years to £131,016, and in 30 years to no less than £267,360! Let users of wasteful engines bear these facts in mind.

PUMPING MONEY.

From "The Engineer."

However singular and startling the above heading may appear, it accurately indicates the nature of the final process in the art of money-making, as practised at the Mint of Great Britain. Without entering into a detailed account of the manipulatory operations by which ingots of gold are transformed into sovereigns, it may be stated that the finishing touch which gives them their impressions and their milled edges, is always administered through the medium of an air-pump. Every coin of this, and indeed of other denominations which have emanated from the Mint since year 1810, may therefore truly be said to have been pumped into the circulating channel. The pneumatic arrangement by which letters or postal packets are pumped through underground tubes from the General Post-Office to Euston-square Station is but a modification of the pump and cylinder system of money stamping in force at the Mint. Should the atmospheric mode of letter carrying be extended to other districts of London as is suggested, the air-pump will become at once our general postman and chief coiner.

Let us proceed to explain the means and contrivances by aid of which the operation of pumping sovereigns is performed on Tower-hill. The prime mover is a steam engine, of 20-horse power, on the combined high and low pressure principle, and which was erected by the Messrs. Rennie. Originally this was intended for pumping water from a deep well to supply the establishment. In 1851, however, Mr. Newton, the Mint engineer, proposed that the engine should be made to pump coins

as well as water, and showed how the thing could be done. The plan was approved by the authorities of the place, and, under the inspection of its inventor, the Messrs. Rennie realized it.

An air-pump constituted the great feature of the scheme. This was made on a new principle, and, while of very simple construction, is found to work with great smoothness and efficiency. It consists of a cast-iron cylinder closely resembling that of an ordinary steam-engine in external appearance. Internally it is very different. The piston is solid, but surrounded by rings of cast-iron, pressed outwards so as to fit the cylinder by the action of steel springs. The base of the cylinder is a hollow casting of iron, or box, and so is its cover. These boxes contain the valves. In each there are 64, and they are necessarily of small size. They are, in fact, nothing more than narrow slips of saw plate, each covering a slot or aperture, and screwed, at one end, to the seat. In both upper and lower boxes 32 of these miniature and silent valves open to the atmosphere, and 32 to the exhaust or vacuum tube. The pump is 42 ins. in diameter, and the piston has a stroke of 36 ins.

By this arrangement of valves, etc., the pump, which is worked directly from the main beam of the engine, is made double-acting; that is to say, it exhausts air during both the up and the down stroke of the piston. A pipe, 200 ft. in length, connects the air-pump with the coining-press machinery. The communication is made over the roof of the building, and therein differs from the pneumatic letter tubes referred to, and which are carried underground. The cost of the whole contrivance, with its accessories, was not more than £400, and after 17 years' working, during which time it has saved the country upwards of £3,000, it has never once got out of repair. Its inventor received *thanks* for his ingenuity, and nothing more. The connecting pipe of the air-pump dips at the proper point through the roof, and is extended downward to a vacuum chamber. This is a cylinder of cast-iron 50 ft. long, and 30 ins. in diameter. It rests horizontally on the floor of the Mint pump-room, and in a line parallel to that of the eight coining presses. Along the top of the vacuum chamber, and each supported by a pipe opening into it, are ranged eight small cylinders without covers. These are furnished with pistons packed with leather, and are placed vertically. Rods, horse-head cranks, and levers, all of light contruction, connect the pistons with the central screws of the stamping presses. It will now be understood that once the air is pumped from below the pistons these latter will descend by force of the atmospheric pressure on their surfaces. They do so really when the great air-pump is in action, and valves below the piston are made to open to the vacuum chamber; the air within the cylinders then rushes down to the exhausted tube, and is discharged again into the atmosphere, whilst the pistons descend to the bottoms of the cylinders, and drag after them the main screws or strikers of the presses. The instant that the dies—one of which is affixed to each screw—advance towards those resting below them, discs of gold are interposed by self-acting machinery, and enclosed by milled collars of hardened steel. By the force of impact resulting from the pistons falling in vacuum, as described, the blanks sustain heavy blows from the upper dies, which thus communicate the impressions that afterward are so much admired. The steel collars form moulds which serrate or indent the edges of the coins, and preserves their circularity whilst being struck. The press screws then rebound, carrying up their respective pistons. The pneumatic valves again open, the dies descend upon new blanks furnished by mechanical fingers. Another batch of sovereigns is pumped into existence, and so long as the air-pump is exhausting the chamber, and fresh blanks are forthcoming, streams of coins, glittering like beetles' wings in the sunshine, will flow down from the presses into reservoirs arranged to intercept and make them prisoners. Thus it is that from day to day, during a gold coinage, the operation of creating sovereigns is carried on at the Mint, and thus it has happened that the Newton air-pump has caused one hundred millions of them, weighing in the aggregate more than a thousand tons, to be added to the gold currency of the world. "Pumping sovereigns by wholesale" would, therefore, be by no means an inappropriate title for the present article.

Before concluding, we would desire to offer a simple suggestion to the Chancellor of the Exchequer. It is this, that in-

stead of carting coins through the streets from the Mint to the Bank of England, or the metal for making them from the latter to the former place, the transport should be effected underground. The distance between the two establishments is not great, and there would be no engineering difficulty and little expense to be incurred in connecting them by means of one or two pneumatic tubes. Probably an up and a down line would facilitate the transit of the precious materials, and another of Mr. Newton's air-pumps, of proper dimensions, is all that would be required in the shape of additional machinery. The present mode of transit is both primitive and unsafe. That which we propose is at once scientific, practicable, economical, and perfectly secure. It is to be hoped that the idea now promulgated may be adopted forthwith by the Government. At any rate we assert fearlessly that its realization would be of infinite advantage to the Bank and the Mint, and at the same time a source of great satisfaction to the public at large. It would form, also, a valuable extension of the system of "pumping sovereigns."

THE WORKING AND VENTILATION OF COAL MINES.

From "The Mining Journal."

Mr. J. Warburton read a paper at the Manchester Geological Society, on Tuesday, on the working and ventilation of coal mines. In the course of his remarks he said that the long-continued depression in the coal trade had forced upon all producers the necessity of economy in order to get a market at all, even sometimes at unremunerative prices. So much had this been the case during the last two years, that he believed a good many capitalists were diverting their money in other directions. Very nearly three years ago he had the honor of reading before this society a paper on what seemed to him to be the best methods to produce coals in a marketable condition, in which he confined himself to the method of getting coal. In this paper he proposed filling in the details as respected the whole of coal production, taking into account ventilation, transit, and all the concomitants of coal producing. He would only say of sinking, that he never yet met with a shaft too large, but he had seen many too small. One other important point he had seen frequently overlooked—namely, the accomodation at the bottom of the shaft. Where a shaft is expected to have drawn through it from 500 to 1,000 tons per day, and must work uninterruptedly 8, 9, or 10 hrs., a good deal of convenient storage room was required at the bottom. He had seen several important collieries seriously crippled at this point; yet going on without this heavy drawback to their efficiency being recognized. After some remarks on underground haulage, in which he expressed a preference for the use of endless chains, he continued: "But there are many collieries where no kind of steam power is applied, but all the haulage done by manual and animal labor. In some of these collieries the haulage expense is very high indeed. It cannot be otherwise where men and boys alone are employed to do this kind of work, and in several places of medium pretensions no other power is employed. I have heard it used as an argument against the introduction of ponies even, that certain seams were too thin to admit them, and with some people this is a fatal objection. With regard to the employment of ponies, small ones are generally secured for collieries, and sought by owners for that purpose. It appears to me that policy is fallacious. If a seam has to be worked, and will pay to get the coal out by small tubs and low roads, will it not pay much better to make high roads and use large tubs? I should say most decidedly it will. So, with regard to ponies, it is much more economical to have one that can draw 16 tubs instead of one that can only take 8 at one time. One lad can do for the former, and less than a lad cannot be employed with the latter. In any case, I would say, let there be large roads, and where animal power is used, large horses, and, in all cases, large tubs. For such is the perversity of underlookers and deputies, that, however large or however small the ponies and tubs, you will be sure to find many roads just sufficient for the tub to go, and no

more. No man or animal can exert his strength in a small space.

A word or two on tubs, corves, or trains. In various parts of the country, there are different kinds and shapes of tubs, some in keeping with the principle of their work, others made regardless of the nature of what they are to do. In South Wales, the Midland Counties, and some places in the North of England, they have wagons much more in keeping with the principle of their work. In Lancashire and Yorkshire we seem to make them as nearly square as we can get them, as if they had to travel sideways as well as endways, thus giving ourselves a broad end for resistance against friction, instead of having the same resistance only for a wagon some 18 ins. to 2 ft. longer. The resistance is not the only drawback. When made nearly square the tubs are much more liable to get off the rails, and much more easily tipped over on the roads if the wheels or axles come in contact with any obstruction. The position of the wheels to each other is also a matter of more importance than is generally supposed. At two separate collieries where I advised an alteration of this kind, the objection raised by both the surface manager and underground steward or underlooker in both places was the same, —by the surface men, that the corves would not twist round so easily if the wheels were further apart; by the underground men (*i.e*, underlookers), that the corves would not lift on the rails so easily when off. These details, to such a society as this, may appear trifles; but it is these trifles in the working of a colliery that go to make up the economy or otherwise. I will give a single instance of the importance of these seeming trifles. I am acquainted with a place where, at one of the pits, up to the end of 1865, they had never been able to draw more than an average of 1,800 tons per week; but by attention to details such as are named in this paper, a weekly average of 3,500 tons were being drawn with ease at the end of 1866. Economy can never be attained with low, bad roads, badly made tubs or wagons, the transit done by manual labor, or even small ponies. I have for some time seen that a great amount of risk and danger is incurred by a too free use of prop wood near the face coal. The true use of prop wood is very little understood. If props at or near working faces are used for anything but temporary purposes, they are expected to do what they cannot do. The sooner, after the coal is taken away, we can let the roof fall the better it is in every respect, both for safety and keeping the next length in better condition. Sprags to keep up the coal till properly holed, and props sufficient to form one or two rows lineable with the working face, are much better than a large quantity set here and there, or any where.

The getting of coal in its most marketable condition should not be sacrificed at the expense of getting the quantity cheap. Economy should be aimed at with this standard in view—that a certain fixed percentage must be in the most valuable condition. This should be the first consideration, and how to do it requires a good deal of skill and judgment. Few will dispute that the largeness of the coal is one of the conditions that constitute value. Also that this largeness should stand transhipping and conveying to its destination with as little depreciation as possible. There is a common expression among coal carriers and colliers in Lancashire that a "square dog-headed coal" is the best for standing knocking about—the expression meaning somewhat of a rhomboid shape, and being intended to convey a distinction between that and the thin laminated coal so easily broken during transit. As a rule, we might say that to get coal as described requires that the coal should be worked at right angles to the cleavage, be holed well and deep, and, if possible, got down by its own gravity, instead of shaking it to death by blasting. Having decided to get the coal in the best manner possible for the market, the next thing is to get it as economically as possible. In my opinion the fixed prices and the mode of fixing them appear to be erroneous. I have known the mode for a quarter of a century, and the same scale obtains now as it did then, though labor, appliances, and all else have altered very much during that time. In Lancashire, as a rule, a coal-getter is everything almost connected with getting, and frequently performs the whole process of preparing—or holing and cutting—the coal, getting it hown by hammer and wedge, or blasting, as the case may be, breaking it out, filling it, and even taking it to the shaft or portway. There seems to me to require

a much wider division of labor. The man who does all may be efficient in all, but he can scarcely be expert in any one of the duties. Amongst our economy we ought to economize the labor of the coal-getters. There are many men old and disabled at 34 years of age through working in strait work. To work economically, in my opinion, would be to work with all the face open, and have neither strait work nor fast boys. I would have the face open all round if need be, and dispense with any cutting whatever. Work at right angles to the line of cleavage. Divide the work; one set of men having to do nothing but holing, another loading or filling, the responsible man having to take down the coal, set the props, draw the back ones, and see to the safety of the place; another set of men to take the roof down in the wagon road, and do the packing at the road sides; and bring a horse to a shunt kept close up to each working place. The first operation after the place is ready is to prepare the coal by holing, which is a very important matter. In Lancashire this holing is done generally at the bottom of the seam, in the coal itself; and, as holing has never formed a separate division or branch, it is done very imperfectly. The colliers of this county are not brought up to deep holing, and what is done has to be done at a great sacrifice of coal, as they "snape" the coal so much to get under at all. If they go three quarters of a yard, the front of the holing must have an opening of from 18 in. to 2 ft. The amount of coal I have seen cut away in this manner is incredible. It is this kind of holing that necessitates the use of so very much powder to get the coal down. When the coal is opened out in long faces, or long wall proper, there is very little difficulty in finding some thin bed of dirt about the bottom to hole in. Even if it were 18 in. thick I would hole in it, and have the whole got up and cast behind the men into the gob, and leave the coal intact. If well spragged and holed 4½ ft., 5 ft., or 6 ft. under, and backed up at the far end of the holing, the whole may be got down in large coal, and, as a rule, without powder, as its own weight will bring it down. Blasting in coal getting is a very unprofitable expedient, apart from the risk that attends it both to men and owners. Where a great deal of powder is used the value of the coal is very much depreciated thereby. Therefore, it cannot be economical to blast coal. Of course there are exceptions, but they would be rare. It is a well-known fact that the least capable men in any colliery use the most powder, and as a consequence produce less valuable coal. Not the least part of economy in getting coal is to get it clean out—that is, leave none in the pit. It has always seemed to me a reflection on the mining faculty, that in computing the amount of coal in a seam it is usual to strike off something like one-fifth of the whole as likely to be lost in pillars or other waste. In seams of ordinary and usual thickness, I see no reason whatever that the whole coal should not be taken abreast of the colliers, clean outright before them. Where pillars are left, to be gotten some other time, they are crushed and broken into slack, and very rarely indeed got out; and pillar getting is always attended with very great danger to the men.

I must conclude with a few remarks on the all-important question of ventilation. To ventilate economically means to ventilate efficiently. It is well known to those who have thought on the subject, that for a colliery to explode there must be a deficiency of good air; there must, too, be much light carburetted gas, and in this condition the mixture must come in contact with flame or fire, and the more this fact is pressed upon those having charge of collieries the better will it be for all. If we were all taught, and thoroughly believed, that collieries could be properly ventilated, I am convinced we should have fewer large explosions; but so long as we can persuade ourselves and the public that an accidental mis-shot can fire a whole pit, so long are we liable to these dire misfortunes. I do not say that a shot cannot fire a pit; but I do say, except there already exist the elements of combustion to very nearly an inflammable point, a shot cannot fire a pit. I am perfectly free to acknowledge that a mis-shot may do a great deal of harm in a confined place, such as the straight work commonly driven in Lancashire; but it seems very unsatisfactory not to be able to account for it. As many serious explosions have occurred simultaneously with the explosion of a heavy or mis-shot, there is a connection, if we could satisfy ourselves what that is. I have given it some thought,

and strongly incline to the following idea: That a mixture of gases just below exploding percentage would become explosive when suddenly compressed. Such compression, I believe, a fast shot capable of producing, and bringing that gas to an explosive point which previous to this sudden compression was not so. This, I think, would take place in the immediate vicinity of such a shot, and the fire that caused the sudden compression would ignite the gas around it, this ignited gas taking up the character of compression and igniting till the whole air, with only one-thirtieth of carburetted hydrogen even was consumed, thus causing a general conflagration in a colliery where the fireman would say, with truth, that he could have taken his lamp top off without fear of an explosion. This could take place only in a colliery very imperfectly ventilated. It is matter of surprise to me that, with the present state of mining knowledge, collieries are to be found with a great amount of capital at stake so badly ventilated; indeed, there are places now working, and ventilating on such systems, that must sooner or later result in an explosion. It is now more than seven years since I suggested for colliery owners such an association for their mutual benefit as the Association for the Prevention of Steam-Boiler Explosions, and I still think it would be of immense advantage. A proprietor would get to know when his colliery was in danger, which is not always the case now. Working on the end of the coal has a special advantage as regards the ventilation. Cutting across the coal is like opening the ends of hundreds of small tubes, and thereby letting out the gas. This is one very great advantage I claim for working coal on end. By such a system we are much less liable to sudden outbursts, as the tubes are always open and drinking the gas from the body of coal. I have prepared a plan by which the cold wind goes direct to the working face, no doors or bratticing in the way; it has no circuitous air-courses to go up and down; it is upon its work at once; and it passes some 150 yards of the face of the working coal, having no other course than that, then retires into a return. There is something special about these returns, as they are all made through the waste, or are made like the other gates or pack roads as we proceed; but there are certain cross roads communicating with the returns from the goaves. These are kept open as indicators, for I find at these places the barometric pressure is less than anywhere else in the pit, and if there is gas in the goaves, sooner than come down on the men at the face it will come at these places, and, being nearer the upcast, drain off, and never come near the men at all. The Oaks was long wall, and on end; but their lowest point of pressure was at the face where the men were working; consequently when the barometer fell the gas came upon the men from the goaves—and, in fact, that was its only outlet. This kind of ventilation is very objectionable. The system also of leaving the goaves behind is open to the same objection, as the lowest point of pressure is where the men are working.

Russian Exhibition of 1870.—The official paper publishes the following notice to intending exhibitors:—"By the terms of the Articles 11 and 12 of the Regulations of the Russian Exhibition of 1870, private individuals, administrations, and societies who wish to exhibit manufactured articles are requested to send a written notice to the principal Commission, or to one of the auxiliary committees, drawn up in the form prescribed, as soon as possible, or, in any case, previous to the 1st of January. The construction of the building being completed, the internal arrangements with respect to the division into classes and so forth are now under consideration, consequently the Commission has the honor to request persons and institutions who desire to compete in the Exhibition to send in their written notices with as little delay as possible, in order that the allotment of space may be proceeded with as speedily as possible. The Commission particularly wishes to have immediate notice with respect to machines that are going to be sent, and of those which it is intended to work in the Exhibition; also of objects which from their weight or volume require special positions and a great deal of space. Printed forms and declarations to be sent with the articles for exhibition may be obtained free of charge at the office of the Commission." Another official notice announces that auxiliary committees have just been formed at Helsingfors, Riga, Yaroslaf, Vladimir, Taschkend, and at Nijni-Novgorod.

MECHANICAL ENGINEERING IN 1869.

From "Engineering."

In these days of railways and iron structures it would be a difficult, if not indeed a hopeless task, to attempt to lay down precisely the line of demarcation separating "civil" from "mechanical" engineering. "Once upon a time," as the old fairy books say, each of these branches of our profession had its own tolerably defined and well-known limits; but that time has passed away, and although broad distinctions still exist, there has arisen—as iron has become more and generally used in engineering works—a broad neutral ground common to civil and mechanical engineers alike. It is not, however, of matters occupying this debatable tract that we intend to speak in the present notice; but rather of those which come strictly within the province of the mechanical engineer, such for instance as tools and labor-saving contrivances of various kinds, and we, moreover, propose to confine our attention to subjects not included under the classes of agricultural or railway engineering or steam engine construction, preferring as we do to treat of these matters independently. Even, however, after these deductions have been made we find that mechanical engineering embraces an extremely wide range of subjects to which it is impossible, within the limited space at our disposal, to do the justice they deserve. On all sides, and in almost all branches of manufactures, we find that mechanical engineers have made *some* progress during the past year; this progress, of course, consisting in many instances, merely of improvements in minor details, while in other cases new fields have been opened for mechanical labor.

Commencing underground, we find that coal-getting machinery has not only in a great measure outlived the prejudices against it, but is beginning to take up an important position amongst mechanical contrivances. Whether "pick" machines or machines in which the cutting of the mineral is effected by a direct planing action give the most economical results, is, however, yet to a certain extent an open question; but we anticipate that it will ultimately—in most situations at all events—be decided in favor of the latter class. Besides the coal-cutting machines proper, of which several new examples—Davies's and Hurd's amongst others—have been brought out during the past year, much attention is now being paid to the use of wedges or hydraulic machinery, as a substitute for gunpowder, for "breaking down" the coal. Mr. J. Grafton Jones, Mr. C. J. Chubb, Mr. D. Davies, Mr. Craig, Mr. S. P. Bidder, Jr., Mr. Cochrane, and Mr. Farum have all brought forward contrivances for this class of work, and with some of them very excellent results have been obtained. Mr. Jones's apparatus consists of a number of plungers set side by side in a steel bar, the plungers being forced outwards, against the sides of the hole in which the contrivance is placed, by hydraulic pressure. Mr. Davies also employs a set of plungers arranged like Mr. Jones's, but he makes the bar flexible by dividing it into lengths jointed together; while in Mr. Chubb's arrangement a set of hydraulic plungers are caused to force apart the bar in which they are set, and another bar forming a cover. In Messrs. Craig and Bidder's, Mr. Cochrane's and Mr. Farum's arrangements, on the other hand, wedges are employed to give the spreading action, Messrs. Craig and Bidder employing hydraulic pressure, Mr. Cochrane screw power, and Mr. Farum the force of percussion, to bring these wedges into action. One great objection at first raised to the use of contrivances of the kind of which we are now speaking, was the difficulty which existed in boring at a moderate cost holes suitable to receive them; Mr. J. G. Jones and Mr. Chubb, however, have each brought forward during the past year arrangements of boring apparatus, calculated to get over this difficulty. There can be no doubt that coal-getting machines of the class above mentioned may be substituted for powder with great advantage, as regards safety of working, in a vast number of cases; but we certainly do not anticipate that they will entirely do away with the use of explosives in mines, nor are we quite certain that such machines can as yet successfully compete with powder, as far as mere economy of working is concerned. Economy, however, should decidedly be

deemed a secondary matter compared with safety in mine working as in other matters.

Closely allied to coal-cutting machines are those employed for rock boring, and in the use of these some advance has been made during the past year. Mr. Fothergill Cooke has, we understand, been making good progress at his slate quarries in North Wales with the boring machine contrived by Mr. Hunter and himself, this machine cutting a tunnel through the slate 6 ft. in diameter. Captain Beaumont's diamond rock-drilling machine, made by Messrs. Appleby, has also been doing good work in Wales, and Mr. Doering has brought out several important improvements in his rock-boring apparatus. Notwithstanding all this, however, and notwithstanding, also, the efficient aid which machinery of this kind has rendered at the Mount Cenis tunnel, and a few other important works, rock-boring machines are still far from meeting with the attention which is fairly due to them —a state of affairs in which we hope to have to chronicle a change next year.

The employment of machinery for stone-dressing is, we are glad to see, making some—although rather slow—progress ; and Mr. Joseph E. Holme's ingenious and simple stone-cutting machine described by us in 1868 has during the past year been brought fairly into practical operation in a number of instances. Other machines and tools for saving the vast amount of hand labor expended—we almost said wasted—in working stone, have been brought out during the past twelve months, and there is ample evidence that this class of machinery is attracting the attention of inventors. Amongst others several new millstone dressing machines of more or less merit have lately made their appearance ; but notwithstanding the immense saving of time and labor by this class of machine we cannot hear that they are being so readily adopted by millers as it was at one time anticipated they would be ; a fact which is no doubt to some extent due to high royalty.

In the machinery of ironworks there has been scarcely any novelty introduced during the past year. Reversing rolling mills, driven direct by quick-running engines on Mr. Ramsbottom's plan, are, however, bidding fair to supplant the old cumbrous rolls with their fly wheels and gearing, while Mr. While's continuous rolling mills are also making steady progress. In the construction of steam hammers almost the only new feature which, so far as we are aware, has been brought forward during the past year is the use—introduced by Mr. F. W. Webb, of the Bolton Iron and Steel Works—of cast steel as a material for the standards and cylinders. We described Mr. Webb's plans in August last.

In the matter of engineers' tools the tendency is still to make heavier and more powerful machines. To a certain extent this tendency has been brought about by the more and more extensive use of steel as a constructive material ; but besides this, the fact is now becoming generally recognized that heavy and powerful tools are a source of undoubted economy. A tool that will clear off in a single cut a quantity of metal that could only be removed by two or three successive cuts in a lighter machine, not only effects an important saving in time and attendance, but it enables a larger amount of work to be got through in a given area of shop room, and renders, to a great extent unnecessary precise and consequently expensive forgings. There are, indeed, a vast number of cases in which it is cheaper, where suitable machinery is available, to bring a rough forging to shape in a lathe or planing machine than it is to forge it more nearly to form under the hammer, leaving the machine tools but light work ; and a knowledge of this fact is now being turned to good account in many of our most important engineering factories.

With the increased employment of heavy tools, the plan of driving each machine by a separate engine is gradually becoming more extensively adopted, and this is particularly the case with punching and shearing machines, and tools of a like character. There is also a prospect of hydraulic power being turned to account in this way, and it is not long since we illustrated an arrangement of hydraulic planing machine designed by Mr. Robert Wilson, and an earlier design for a similar machine, by Mr. James Fletcher.

Another feature connected with tool-making, which has received considerable development during the past year, is the construction of machines adapted to special classes of work. It is scarcely possible nowadays to go through any

engineering factory of repute without noticing a greater or less number of machines which have been specially constructed for the class of work in which their owners are principally engaged ; machines, perhaps, which would be of comparatively little service in another establishment, but which, in their proper places, effect an immense saving of labor. This is decidedly as it should be, and we expect during the next few years to find that these special tools will come more and more largely into use, and that they will, to a great extent, supplant machine tools of the ordinary standard forms. Another matter in which some progress has been made during the past twelve months, and in which we anticipate a more rapid advance in the future, is the adoption for many classes of work, of the copying principle. In our gun factories this principle has for some years past been turned to most successful account, and by its aid not only has great economy of production, but increased accuracy of workmanship been secured ; yet notwithstanding this the application of the principle to the finishing of work of a heavier kind has made slow progress in this country. Of course the principle can only be economically adopted where large numbers of articles have to be turned out to one pattern; but even with this restriction there are vast fields for its employment. With the more extensive adoption of the copying principle must come the increased employment of the milling tools or revolving cutters so extensively used in America, and yet so comparatively little used here; while the increased employment of milling tools again will lead to the manufacture of new machines for making them.

In wood-working machinery there have been but few complete novelties brought out during the past twelve months, although many improvements have been introduced in machines already known. We must, however, make mention of Fraser's double-saw frame, lately described by us, and of Parkinson's "universal joiner"—a machine lately introduced by Messrs. Allen, Ransome & Co., and of which we shall probably give a description next week. Wood-machinery manufacturers, like engineers' tool makers, are gradually doing more and more in machines for special classes of work, and it is in these, in fact, that the principal novelties are to be found.

It would be impossible within the limits of an article like the present to even enumerate the names of the numerous new machines for miscellaneous purposes which have been brought out during the past twelve months, but at the same time there are many of them which it is equally impossible that we should pass over without notice. Foremost, perhaps, amongst these is Mr. James Lyall's admirably ingenious "positive motion" loom, which we fully described a few months ago, and which is now being exhibited at work in Manchester ; while Taylor's tube-rolling machine, turning out metallic tubes at the rate of 60 ft. run per minute, is another important invention, of which a good deal more will yet be heard. Then again we have Messrs. Kittoe and Brotherhood's apparatus for sinking screw piles by steam power, Messrs. Shaw & Justice's gunpowder pile driver—both inventions calculated to do contractors good service in certain situations; Mr. John Cooke's simple mine ventilating machine ; and, passing on to other labor-saving contrivances, Goff's wrist-pin lathe, Batho's nut-shaping machine, Crowe's universal tables for drilling machines, Burdett's brick-cutting table, Beeley & Hanson's welding machines, Halliday's and Daglish's arrangement for oiling colliery wagon axles, Michaud & Jay's automatic weighing cranes, and numerous other appliances of a similar class which we cannot even mention. Then, also, there is Aston & Storey's continuous indicator, one of the most ingenious inventions of the year, and one, moreover, which, if properly appreciated, will be of great benefit to all users of steam power.

We must now, however, bring this notice to an end, and in doing this we are fully sensible that we have by no means exhausted the subject of mechanical engineering progress during the past year. We have, however, we trust, said sufficient, when taken in connection with the independent articles which we intend to give on certain special branches of what we may term manufacturing engineering, to prove that our mechanical engineers have not been idle during the past twelve months, and that if trade has not been in a very flourishing condition, there has not been any lost ground on that account.

BUILDING MATERIALS AND APPLIANCES.

From the "Building News."

TERRA COTTA *versus* MASONRY.

The manufacture and uses of terra cotta have more than once been discussed in our pages from various points of view, and our readers will remember that strong opinions have been expressed with reference to the proper method of dealing with this material. As our title implies, we now propose to consider the relation it bears to stone work; for, after all, the main point which has to be regarded in connection with terra cotta is its future prospects in the competition with masonry, not merely for decoration but also for structural purposes. It may be as well at the outset to define what we wish to imply when we speak of the employment of terra cotta for the purposes of construction. We mean that terra cotta is too frequently looked upon as a mere fancy material, such as is papier-mache or carton-pierre, and its use is limited to window-dressings, spandrels, and similar decorative features—stone or iron being made to do the real work, while terra cotta is merely introduced for display. Now, we maintain that terra cotta is a genuine building material, just as much as brick or stone is; and in places where terra cotta cannot be employed, so as to do the work it professes to do by itself, it should not be used at all. It is quite as strong, if properly made, as brick, and by backing it in with cement it can be made to bear as much as Portland stone. There is not the slightest necessity for giving terra cotta cornices such a projection that they have to be held in place by York landings, or for making terra cotta columns hollow, and inserting cast-iron stanchions in the centre of them in order to take the weight; such shams as these are quite unworthy of the material. We desire, therefore, when we speak of its constructive use, to impress the fact that it should do the work it is represented to do, independently in any position in which it may be placed in a building.

If we go back to the early history of the revival of terra cotta in this country, about the commencement of the present century, we find that terra cotta was introduced about the same time as stucco and cast cement as a substitute for stonework. It then received numerous fine names, such as lithodypyra and lithargolite; but it was chiefly known as artificial stone. None of these grand names have survived, and it has come by universal consent to be called by the Italian word which signifies baked or burnt clay. Our object in reverting to the reappearance of terra cotta in England is in order to notice the circumstances under which it was ushered in, and to point out the difficulties against which it had at first to contend. The demand for terra cotta was then solely in the shape of shams or imitations of stone, such as keystones for the doors of the Harley-street period, consoles for windows, coats of arms for shop fronts, and all the pretty enrichments which the builders of that day considered necessary for their "first-class family mansions." Stucco, that most odious of all shams, was not then permitted to veil every defect and shortcoming in material and construction, and if the architecture was ugly, it was, at any rate, what it pretended to be. Now, it will at once be seen that terra cotta, commencing in the way we have described, began its career under false pretences; and it was most likely owing to this that in the struggle with stucco it was vanquished, and from the time of Coade until the Exhibition of 1851, we hear very little about it. Its failure may almost, however, be regarded as an advantage, inasmuch as the modern treatment of terra cotta, being based upon a better comprehension of the material, gives it a chance of a fairer and more reasonable trial than before. But we must not, as there seems some tendency to do, overlook the lesson which this defeat should teach us; and if terra cotta is to become an English building material it must be looked upon and treated as terra cotta, and not as artificial stone. As baked clay it has, in a country where brick is by far the most common building material, a strong claim upon our attention, and if honestly and properly made use of, there appears to be but little doubt of its being very generally employed.

We will now endeavor to show what we consider is the proper way of using terra

cotta. In one word we may explain this to be as a *brick*, or, better, as a superior kind of brick made of the finest and purest kind of clay, and specially calculated, on account of its durability and power of resisting discoloration, for the reception of such ornamental details as may be required in a brick building. It should be made, chiefly for manufacturing reasons, in small pieces, and in such size as will take up with a certain number of courses of brickwork. If larger than a brick it should be made hollow at the back or sides, in order that it may be well bonded in with the surrounding brickwork, and it should never be introduced into situations where these conditions cannot be satisfied; or, better, the architectural character of a brick building must be modified and fitted to receive brick decorations. We are persuaded, and we think that all must admit, that it is extremely wrong to employ terra cotta in places where it is necessary to string it or hang it out upon iron supports in order to give it an unnatural projection, or to plaster it in thin veneers of ashlaring against flat surfaces upon which it has no other hold than that of the cement in which it is bedded. If we refer to the Italian terra cotta work, we find that this common-sense method of dealing with the material is everywhere seen: in the Certosa near Pavia, the Ospedale at Milan, and the numerous brick buildings of Northern Italy. We question if any blocks over a foot could be found, and in the cornices and mouldings it was the universal practice to give an increased depth to make up for the want of projection.

Another common error with regard to terra cotta is the belief that, as it is a plastic material in the earlier stages of its manufacture, the blocks may be varied to any extent, and that it is possible to get any requisite number of changes of form without extra charge. Now, if we remember the way in which the blocks are produced, we can at once see the folly of this notion. Each change of pattern requires a fresh model and a fresh mould, or fresh moulds if there are many of each block, and it is not to be expected that manufacturers will introduce changes involving so much expense without extra charge, merely for the sake of variety. As a cheap material, the more blocks used of a pattern the better. We have frequently heard people say when alluding to terra cotta, that it possessed great advantages over masonry, inasmuch as you get the touch of the artist's own hand instead of the translation of it into stone or marble by the mason's chisel. But this, although true in a way, does not hold good with modern work so much as it might do. When the ornament is modelled in terra cotta clay, and then taken away and burnt, you do indeed get the untouched work of the designer; but if, as is more commonly the case, the clay model is cast in plaster and then moulded or piece-moulded, it too frequently happens that the reproductions from the mould undergo a scraping and finishing process with a sponge or a wash-leather, which is quite fatal to any artistic touch the original design might have possessed. There is, however, really no necessity for this dressing, and if the joints in the mould do leave little ridges on the blocks, we had far rather see them remain there than have them removed at the expense of the whole of the feeling of the design. It is hard to find so much fault, but as we have the interests of terra cotta warmly at heart, we must point out one other defect in the modern terra cotta—namely, in the design of the ornament for it. This blame will of course only fall indirectly upon the manufacturer, as he must be guided, to a great extent, by what suits the public taste in these matters, and any protest of ours must be addressed as much to the public as to him. We cannot but hope, however, that any alteration for the better in the design of terra-cotta work would be appreciated, for anything more hideous than the ordinary run of manufacturers' stock in this material cannot well be imagined. We are afraid even to commence to criticise the vases and garden ornaments one commonly meets with—they are beneath criticism; but even in the articles of a more architectural character in brackets, balusters, and enriched mouldings, one rarely meets with anything that is good. The tendency in terra cotta ornament is towards an indifferent cast-iron treatment, or a hard metallic-looking decoration, applied to debased Grecian forms which have in all probability been handed down from the earliest days of Nash, or even from the commencement of the Classic rage in George the Third's time, and are, in fact, nothing but servile copies of iron-work. Now, there is no

need of such bad design nowadays. We have amongst us a school of designers who are capable of better things, and we believe it would be worth any enterprising manufacturer's while to get some new models to replace the atrocities he is now guilty of. There is not the faintest pretext for making terra cotta so like cast-iron that if it were black-leaded, you would not know them apart; this is a fault quite as bad as the artificial stone treatment we have been complaining of. It is true that in both cases the work has to be moulded, but the mould used for terra cotta is widely different from that for iron. Under-cutting in terra cotta entails, as we must admit, rather more trouble than plain work; but to an experienced moulder there is less difficulty than one would imagine, while in the case of mouldings, which can be run out on the bench, it makes no difference at all. We may mention here that the method of running mouldings on the bench with a strickle, which saves an enormous amount of time and trouble, appears to be but little practised by manufacturers.

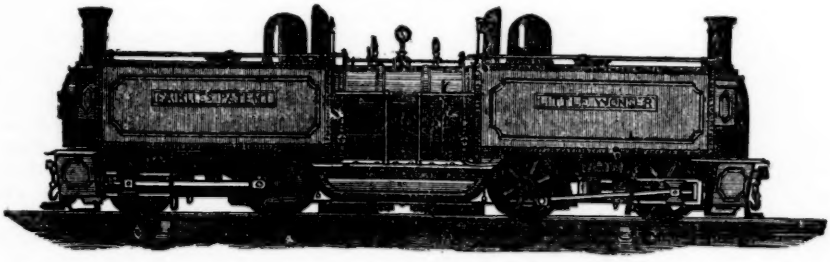
For architectural work the character of the design of the terra cotta is a most important consideration, and on this point we feel there can be little diversity of opinion. The relief of the ornament must never be obtrusive, or calculated to mar the outline of the surfaces to which it is applied; the lines should be flowing rather than stiff or constrained, as in iron chasing, and the feeling should be rather that the design has been wrought in a soft and plastic material than stamped, impressed, or cut out in a hard and unyielding one. We fear that in the effort to make terra cotta look crisp and nicely finished, this latter quality is too often attained by our manufacturers. We have as yet said but little, except by inference, about masonry, and we will endeavor, in conclusion, to show the bearings of our observations upon the special subject we proposed to ourselves. The point we would impress is, that for brickwork terra cotta is the proper decorative material, and that stone is just as out of place in a brick building as terra cotta is in a stone one. If it so happened that stone was cheaper than brick, we would still maintain this theory, but as this is not the case, we have a strong argument in favor of terra cotta. It is needless to induce reasons or precedent in support of this, as it depends upon a fact which can scarcely be questioned—namely, the relative fitness of these materials for the decoration of brickwork.

In the matter of price, we cannot too strongly urge upon manufacturers the necessity of producing terra cotta which shall be *cheap* as well as good. It is rather the way in the trade to make a great fuss about the composition of the ware, and to talk learnedly about powdered glass, calcined flints, pegmatite, etc., etc., even making a secret about the proportions of the constituents; whereas we can once and for all assert that the pure fire-clay of the coal measures is all that is necessary for the manufacture of a most durable and excellent material. There can be no great harm in adding the substances we have enumerated, it is true; but why have them in if the clay is just as well without them, especially when they are not forgotten in the price? Fire-clay, composed, as it is, almost entirely of silica and alumina, will stand the utmost heat to which it can be exposed in the kiln, and when once thoroughly fired such clay is almost imperishable. We have seen a specimen of fire-clay terra cotta, which has been for months in (commercially) pure oil of vitriol, the surface of which was perfectly uninjured and untouched by the acid. Well burned fire-clay is, if anything, less absorbent than a body composed of mixed materials, and certainly less so than Portland or the best of our building stones, granite only being excepted. It will be evident that in the case of plain mouldings, which can be run with a strickle, or simple enrichments, many of which will be required for each mould, there can be no comparison with stone in the matter of price, but even in the case of complicated designs, of which only one or two copies are needed, terra cotta can well compete with masonry in this particular. Perhaps one of the greatest arguments we can bring forward in favor of burnt clay is its beautiful and varied color. Instead of a grimy, soot-stained surface of stone or brick, we have a bright, non-absorbent material, which in color can be compared with nothing but marble, as seen in ancient buildings in Italy, where it assumes the richest and most varied tints,

and excels any English building stone we know of. We have thus noticed the advantage of terra cotta in the matter of fitness, of color, and of cost. It only remains for us to impress strongly on our readers these concluding points, to which attention must, we feel convinced, be paid, in order that terra cotta may succeed in the struggle for public favor. Manufacturers must learn that terra cotta can be produced much more cheaply than it has been up to the present time; architects must make themselves acquainted with its peculiarities, and with the best mode of dealing with them; and the public must find out, from a few good examples, that terra cotta is capable of being employed with excellent effect as a genuine constructive material, and, as such, of supplying one of our chief wants—namely, a good cheap decoration for our brick buildings.

THE "LITTLE WONDER:" FESTINIOG RAILWAY.

From "Engineering."



The seventh and last engine constructed for the 2 ft. gauge—the Festiniog Railway—was delivered some weeks ago, and is now working. As will be seen from the illustration, it is upon Mr. Fairlie's patent system. It has four cylinders, $8\frac{1}{8}$ in. in diameter, with 13 in. stroke and 2 ft. 4 in. (28 in.) coupled wheels. The tanks contain 1,000 gallons of water, and the whole weight, in steam, is estimated at about 20 tons. The total wheel base is 19 ft., each bogie having its wheel centres spaced 5 ft. apart. For each pound of average effective pressure on the pistons 60 lbs. of tractive force are exerted at the periphery of the driving wheels, or, with 100 lbs. mean effective pressure, a total force of 6,000 lbs. The "Little Wonder" is worked at a boiler pressure varying from 160 lbs. to 200 lbs., the boiler, of Sir John Brown's steel, being 2 ft. 4 in. in diameter, $\frac{3}{8}$ in. thick, and double riveted in the longitudinal seams. The engine easily hauls from 100 to 150 empty slate trucks up the line, or, say 100 to 150 tons, including its own weight, on a line, rising, on the average, 1 in 92, and occasionally 1 in 80. Nothing can exceed the steadiness of this engine in passing the curves of from $1\frac{3}{4}$ chains to 4 chains radius, and the speed already attained has been timed at 35 miles an hour.

The railway is the most wonderful one in the kingdom.

Chinese Surveyors.—The processes of "levelling" are conducted by Chinese surveyors in a very primitive fashion: "The instrument employed is a modification of the water-level—an oblong trough of buckthorn or other similar wood, clamped with iron, and open at the ends. The interior surfaces of the sides are ruled horizontally with fine parallel lines in red or black paint, to serve as guides to the observer's eye. The trougo is suspended by a single cord from a hook fastened beneath the apex of a wooden tripod stand. The usual height of the latter is $4\frac{1}{2}$ ft. The instrument is adjusted by pouring water into the trough—which is deeper in the centre than at the extremities—and then shifting the suspending cord or the legs of the tripod until the surface of the water coincides with a pair of the horizontal lines."

PRESENTATION OF THE RUMFORD MEDALS.

From the "Boston Advertiser."

By a letter dated July 12, 1796, addressed to John Adams, Count Rumford requested the American Academy of Arts and Sciences to accept $5,000 in United States stock, the interest to be applied to premiums, to be given to the authors of the most important discoveries, or useful improvements, which shall be made in any part of the continent of America, or in any of the American islands, on heat or light; the preference always being given to such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind. To be given in two medals, one of gold and one of silver, together of the intrinsic value of $300. At a meeting of the Academy held in this city last evening, these medals were presented to Mr. George H. Corliss, of Providence, R. I., for his improvements in the steam-engine. The presentation was made by Dr. Asa Gray, President of the Academy, with the following remarks:

ADDRESS OF THE PRESIDENT.

Gentlemen of the Assembly,—At the last anniversary meeting, after a careful investigation by your appropriate committee, you awarded the Rumford medal to Mr. George H. Corliss, for improvements of the steam-engine. The gold medal and a silver duplicate have been struck and are now before us. The inventor, whose genius you have thus recognized, has responded to our call, and is now present. If it be your pleasure these medals will now be consigned to his hands.

Mr. Corliss,—The trust which our countryman, Count Rumford, charged this Academy to administer, empowered it to award these medals "to the author of any important discovery or useful improvement on light or on heat, which shall have been made and published by printing, or in any way made known to the public, in any part of the continent of America or of any of the American islands; preference being always given to such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind."

As this is only the fifth occasion since the foundation of the trust, upon which this premium has been given, it may well be inferred that the Academy has in no case bestowed it inconsiderately.

It has required the discovery or invention to be real, original, and important. It is not restricted to considerations of direct practical benefit, but it may, as it did in the first instance, in the case of the oxhydrogen blow-pipe, honor a discovery of much scientific interest, the uses of which are limited. It would not hesitate to crown any successful, however recondite or theoretical investigation within the assigned domain, being confident that no considerable increase of our knowledge of the laws and forces of Nature is likely to remain unfruitful. But the Academy rejoices when, as now, it can signalize an invention which unequivocally tends to promote that which the founder had most at heart, and commended to our particular regard—the material good of mankind.

Without entering into details, it will be possible to state the ground upon which the present award has been made. It is for the abolition of the throttle-valve of the steam-engine, and the transference of the regulation by the governor to a system of induction-valves of your own invention; with the advantage of a large saving in fuel, and, what is often more important in manufacturing industry, the maintenance of perfectly uniform motion under varying work.

Previous to your improvements the regulation of the power and velocity of the steam engine was universally effected by an instrument placed in the steam pipe, well named the thottle-valve, being used to choke off the steam in its passage from the boiler, to reduce more or less its pressure before it was allowed to act within the engine. Avoiding this wasteful process, your engine embodies within itself a principle by which it appropriates the full, direct, and expansive force of the steam, and measures out for itself at each stroke, with the utmost precision, the exact quantity necessary to maintain the power required.

In the most approved engines previously used for manufacturing purposes, the valves employed were comparatively difficult to operate, too far from the piston, and in other respects unfit for working in connection with the governor. Their abandonment and the substitution of

others suitable for the purpose that you had in view, demanded an entire change in the structure of the engine.

In the reconstruction your mastery of the resources of mechanism is conspicuously shown; you introduced four valves to the cylinder, two for the induction and two for the eduction of the steam; and by your device of a wrist-plate you give to each valve a rapid motion in opening and closing, and a slow motion after the closing has been effected, thus securing a perfection in valve movements never before attained. The special object of these changes, and the gist of your invention, was to place the induction-valves under the control of the governor, by which they are operated in opening through a mechanism from which they are released earlier or later in the stroke of the piston, according as more or less power is demanded of the engine—the governor, with extreme sensibility, determing the point where the supply of steam should be cut off. Thus, at every stroke of the piston just so much steam is accurately meted out to the cylinder as is needed to maintain uniform velocity, and left to expand then, and by its expansion develop the maximum of propelling force.

Allow me to read to the Academy a brief account of the Corliss engine, by one of the most eminent of British engineers, Mr. J. Scott Russell, which must needs be free from personal or national prepossessions. It is from one of the official reports on the Paris Universal Exhibition of 1867 :

"A third remarkable engine is American, both in invention and execution, and forms perhaps the most remarkable feature of the American department. It exhibits thoughtful design, ingenious contrivance, refined skill and admirable execution. It is singularly unlike an English engine. It has four ports on four different parts of the cylinder, two on one end and two on the opposite, each worked by a separate mechanism. These ports are worked by valves, not sliding, like our own, on flat surfaces; but sliding valves on cylindrical surfaces. Close up to the cylinder these valves cut off the steam with scarce a particle of waste room, and so economize to the utmost the high pressure of steam which they admit, and which they use as expansively and as sparingly as possible. The mechanism by which these valves are moved, is to our eye outlandish and extraordinary; but it is, in truth, refined, elegant, most effectual and judicious; it spares steam to the utmost, but develops what it uses to most effect. Then it proportions in an admirable way the doses of steam it serves out to the continually varying quantity of work the engine has to do. The mechanism of its mechanical governor is wonderfully delicate and direct; the governor is sensitive to the most delicate changes of speed, and feels the slightest demand upon the engine for more or less work and steady speed. A mechanism, as beautiful as the human hand, releases or retains its grasp of the feeding-valve, and gives a greater or less dose of steam in a nice proportion to each varying want. The American engine of Corliss everywhere tells of wise forethought, judicious proportion, sound execution and exquisite contrivance."

It appears that within the twenty years since this machinery was perfected, more than one thousand engines of the kind have been built in the United States, and several hundreds in other countries, giving an aggregate of not less than 250,000-horse power ; that as to economy of fuel, evidence has been afforded to the Rumford Committee, showing a saving over older forms of engines of about one-third. As to its other crowning excellence, uniformity of velocity, the purchasers of one of the engines, now in its eighteenth year of service, certify that, with the power varying from 60 to 360-horse power within a minute, the speed of the engine is not perceptibly affected.

It is worth noting that when these medals were voted to you, Mr. Corliss, just a century had passed since James Watt patented his improvements of the steam-engine. The vast results of these improvements—the difference between the engine when Watt found it and when he left it—make one of the most important chapters in the history of applied science. It is a great thing to say, but I may not withhold the statement, that, in the opinion of those who have officially investigated the matter, no one invention since Watt's time has enhanced the efficiency of the steam-engine as this for which the Rumford medal is now presented to you.

If Watt, or his partner Bolton, could boast that they held the supply of that which almost everybody longed to have, *power*, you may justly felicitate yourself, and permit us to felicitate you, upon your ability to supply a greater amount of steam power for the expenditure, and an exacter nicety it its governance, than any of your predecessors.

In acknowledgment of this benefit, the American Academy, administering Count Rumford's trust, now, by the hands of its presiding officer, presents to you these honorable testimonials of its high appreciation of what you have done. And the Fellows here assembled, join with me, I am sure, in most sincere and hearty wishes that you may long enjoy this and similar distinctions, along with more material rewards of your genius and will; hoping, also, that these may still be fruitful in yet other inventions, redounding to your honor and advantage and to the promotion of the good of mankind.

Mr. Corliss accepted the medals, and replied as follows: "Mr. President: Competitive honors are the reward of efforts, stimulated by rivalry and ambition. This honor comes from gentlemen who scan the whole field of science and art, and in deliberate council make their awards in discharge of a sacred trust. To this consideration I add the historical associations connected with the American Academy of Arts and Sciences, and the scientific fame of its members; and I receive this testimonial with grateful acknowledgment of a distinguished honor."

BRIDGE CONSTRUCTION, 1869.

From "Engineering."

Bridge construction has been advancing rapidly during the past year, and principally in the United States. Nature has been kind to American engineers in giving them great obstacles to overcome, while necessity has rigidly limited outlay; and hence arises a special fertility of invention and a special class of work.

But Holland has been building large bridges too, and Russia is just commencing on a greater scale than any other European country. Hitherto her railway bridges have, for the most part, been made of timber, and are to be replaced. Especially on the Nicolai Railway, it has been recently decided to reconstruct sixty-eight wooden viaducts—a decision hastened through the destruction of one 1,200 ft. long by fire. Not much has been done as yet in Hungary, but last year saw the preliminary measures taken for a large amount of heavy bridge work in the future. The great bridge crossing the Hollandch Diep—the Waal and Maas estuary—to join Antwerp and Amsterdam by an unbroken line of railway, is in progress. The contracts for this work were let to Van Vlissengen and Van Heel, of Amsterdam, just at the termination of 1868, for a price of £122,260. The bridge is in 14 openings of 328 ft. each. A main line, undertaken by the State in 1860 for the purpose of connecting Belgium and France with the central part of Holland, has involved in its length the construction of 3 large bridges within a distance of 10 miles, over the Maas, the Lek, and the Waal, the two former of which are the channels by which the Rhine reaches the sea, and over which important bridges at Bommel and Crévecœur are in course of erection. The former of these, which is now on the point of completion, consists of 8 openings, each of 187 ft., and 3 of 393 ft. 8 in. Its cost has been £271,625. The Crévecœur bridge crossing the Maas has 10 openings, each of 187 ft., and one main span of 328 ft. This work, which has been undertaken for the sum of £93,000, will not be finished until the close of the present year. In the north of Holland, also, the railway between Zwolle and Leuwarden has been completed by the bridge across the Ysselin, 10 spans, one of which is 321 ft. 6 in. in the clear, the rest of the viaduct being made up with smaller openings, among which is a swing span of 51 ft. 6 in. in length.

Towards the close of the year a suspension bridge across the Moldau, at Prague, was opened for traffic. It is intended for foot passengers only, and is 629 ft. in length, the space being divided with a central pier. The width of platform is very inconsiderable, being only 11 ft. It is worth noting that the links forming the

suspension chains are of Bessemer steel; the contract price was £18,500.

In February last a stone bridge at Fucecchio, over the Arno, was completed. It consists of 5 arches of about 74 ft. each, and cost some £8,500.

The arched bridge of Bessemer steel which, it will be recollected, carried the Quai d'Orsay over the road between the Exhibition and the bank of the Seine, has been removed, and re-erected on its permanent site over the Vilaine, at Port-de-Roches. In its temporary position the arched girders, 11 in number, had one clear span of 82 ft., so as to obtain the necessary width. In its present position, however, it has been lengthened out into 3 spans, each composed of 4 ribs, giving a width between the parapets of 19 ft. 8 in. The total cost of the steel work of this bridge was but £2,612.

We have to turn, however, to America to find the great examples of bridge construction during the past year. The extension of railways westward, across the great rivers of the Continent, have involved much work; but two of the principal bridges are in progress to effect a metropolitan communication. Of these the first is that intended to connect New York city with Brooklyn, and will span the East River with a clear stretch of 1,600 ft. This was Mr. John A. Roebling's last and greatest work, at the first stage of which he lost his life. The bridge is, however, being carried out by his son, and when completed will be the largest in the world. During last year the caissons for the foundations have been partially built, and considerable excavation on the site of the piers is being carried on. When completed the towers will have a total height of 300 ft., and will carry the wire cables, from which will be suspended a double roadway for passenger and street railway traffic.

Second in importance is the arched road bridge over the Mississippi at St. Louis, with its central span of 515 ft., and two side arches of 497 ft. each. This enormous structure, designed for railway as well as passenger traffic, is well in progress, under the superintendence of its engineer, Mr. James B. Eads. It will be remembered that we have described this work at great length in the sixth volume of "Engineering," and that on page 345, we published a large engraving showing its general design, as well as the details of its construction. Its total cost will be about £640,000.

The Quincy Bridge, although actually opened for traffic in 1868, may be included amongst the last year's bridge-work of the States. This is the longest bridge spanning the Mississippi, the river at the point of crossing being 3,250 ft. in width, the navigation channel, however, being only 800 or 900 ft. broad. The bridge is divided into seventeen spans, two of 250 ft., three of 200 ft., eleven of 137 ft., and one large draw span 360 ft. long, the girder of the latter being 36 ft. in depth. The piers of the fixed spans are all of masonry; that of the swing is formed of four wrought-iron cylinders 14 ft. in diameter, sunk through 50 ft. from the water level; upon the top of these a turntable, 30 ft. diameter, rests, and carries the span. The total cost of the work, designed and carried out by Mr. Thomas C. Clarke for the Quincy Railroad Bridge Company, was £215,000.

At Omaha, in the State of Iowa, four railway companies—the Union Pacific, the Chicago and North-Western, the Chicago and Burlington, and the Chicago and Rock Island—combined last year in the construction of a long bridge across the Missouri, designed by General G. M. Dodge, the Engineer of the Union Pacific Railroad. This bridge is 2,800 ft. in length, divided into 11 spans of 250 ft. each, resting upon concrete filled cast-iron cylinders 8 ft. 8 in. in diameter. Some of them require to be sunk to a depth of 70 ft. below low-water mark, making the total length of column 139 ft. The superstructure of this bridge is formed of ordinary wrought trussed girders, with cast-iron top member. In addition to the bridge itself, approaches three miles in length are also required, principally formed of trestle work.

Action has also been taken in the matter of the Cornwall Bridge, to cross the Hudson river, about 40 miles above New York city. The total length of this work, with approaches, will be 2,500 ft., the clear span 1,600 ft., the same as that of the East River bridge, and the height of the towers 280 ft. The platforms, railroad and passenger, would be carried by wire cables (70,300 miles of wire would be required), upon Mr. Roebling's system, and the estimate of the

whole work is £500,000. The main object attained by this bridge would be the transfer of the vast coal traffic of the Hudson river to the railway companies between Pennsylvania and the New England States.

Last January, a new bridge across the Niagara river, about half a mile below the Falls, was opened for general traffic. This work was erected by Mr. Samuel Keefer, for the Clifton Suspension Bridge Company, under two charters, one from the State of New York and one from Canada. The total authorized capital was $400,000.

This magnificent bridge spans the gorge of the Niagara river, where its depth is 180 ft., and its rocky sides rise up some 80 ft., to the level of the table land above. The span between the points of suspension is 1,268 ft. 4 in., and the deflection of the cables in the centre is 90 ft. The towers are 100 ft. in height, built of white pine, and disposed in pairs, each in the form of a truncated cone, 28 ft. square at the base, and 4 ft. square at the top. The towers are placed 13 ft. apart (in the clear) at the base, and they are braced together at intervals for their whole height. Two cables carry the platform over the towers, where they are 42 ft. apart, converging to 12 ft. apart at the centre of the bridge. Each cable is composed of 7 ropes, twisted from 7 strands, and every strand contains 19 wires, 155 in. in diameter. All the wires in the cables were drawn in one length, so that the cables are without splice or weld from end to end.

The platform is supported by a combination of diagonal and vertical rods; of the former there are 48 in all, reaching from the towers half way to the centre of the bridge. They are formed of wire rope varying in diameter from 4¼ to 3 in., according to their position. The vertical suspenders are also of wire rope $\frac{5}{8}$ of an inch diameter, and placed at intervals of 5 ft. There are altogether 480 of these, representing an aggregate strength of 4,800 tons. In addition to these supports, 54 guys are introduced to steady the platform, of these 28 are on the up-stream, and 26 on the down-stream side. These extend nearly to the centre of the bridge and are moored into the rocks on each side. The roadway is stiffened by a light wood and iron longitudinal truss, 6 ft. 6 in. deep, and going down 2 ft. 6 in. below the platform level. Transverse floor beams of pine, bolted together in pairs, and placed in groups at intervals of 5 ft., rest upon the longitudinal girders, and upon these is placed the flooring, formed of two thicknesses of pine 1½ in. thick.

In Philadelphia, a new bridge across the Schuylkill has been set in hand, with two platforms, the one to remove the railway from the level of the streets through which it ran, to the infinite inconvenience of the street traffic, and the other to effect an improved communication between the large streets of the city. When completed, this bridge will have a clear span of 340 ft., a width of 50 ft., and a depth of truss of 35 ft. The work is being carried out by Mr. J. Linville, of Philadelphia.

On the New Haven, Middletown, and Willimantic Railroad, between New York and Boston, a bridge to span the Connecticut has been decided on. Its total length is 1,248 ft., and 2 of the spans will be formed to swing, with openings of 160 ft. each. The clear headway above the water is 42 ft., and the depth of the truss is 20 ft.

At the beginning of last year an important bridge over the Mississipi, at Dubuque, Iowa, was opened for the accomodation of the Union Pacific Railroad. Its total length is 1,760 ft., divided into 7 spans, the principal of which is a swing of 460 ft. long, and turning on a centre pier 20 ft. in width. This bridge was constructed by the Keystone Bridge Company, of Pittsburg, in less than 8 months.

Lastly, among American bridges of the past year, we may mention the great work across the Missouri river at Kansas City, designed and erected by Mr. O. Chanute, and representing one of the most successful examples of bridge construction in America. The total length of the bridge is 1,387 ft., divided into 7 spans, one of which is a draw span 363 ft. in length. Besides the bridge itself the approaches involved the construction of 2,360 ft. of trestle work viaduct. We have so recently described this work, that we need hardly refer to it again in any detail; it will be remembered that the great difficulties lay in the foundations, and that the rapid current, the impetuous floods, and the ever shifting bottom, brought about some failures, and necessitated an

almost unprecedented amount of skill and care on the part of the able engineer to whom this work was intrusted.

At home, with two notable exceptions, we have but little to show for the past year's work in bridge construction.

At Halifax, a cast-iron arched bridge, in 2 spans, by Mr. John Fraser, of Leeds, has been completed; the openings are each 160 ft., with a rise of 16 feet. The architectural effect of this bridge is good, and the spandrel filling and parapet well designed.

The two great metropolitan bridges have been finished this year—the Holborn Viaduct and Blackfriars Bridge.

At the Woolwich Arsenal, the pier designed by Mr. J. W. Grover, for the shipping and unshipping of guns, is in progress. This pier has a total length of 328 ft., divided into 6 spans of 48 ft. each. The width of the platform is 22 ft. 6 in., and the size of the pier-head is 40 by 50 ft. A 30 ton crane, resting upon a 7 ft. diameter cylinder, is placed at the end of the pier. The cost of this work will be £10,000.

The proposition for the widening of London Bridge has been seriously discussed during the past year, and many schemes have been submitted to the consideration of the Common Council. Of these we need only say that not one, which proposes to add considerably to the width of the platform, whether by cantilevers, or girders placed alongside the existing structure, at all fulfils the requirements of the case. It is not likely that any action would ever be taken to carry out alterations which would mar the bridge entirely; but it is an aditional security that the foundations of London Bridge have all their work to do in carrying the structure as it at present stands, and that any additional load could not be safely applied. Meanwhile attention is turned towards the practicability of making Southwark Bridge convenient for ordinary passenger transit, and by so doing to divert part of the London Bridge traffic.

A new bridge across the Thames at Wandsworth has recently been proposed, and will doubtless be decided upon. The design, however, has not yet been prepared.

Finally, we may refer to the Pons Asinorum, or Boutet's Bridge, designed to cross the Channel between Dover and Calais, in any number of spans desired, and comprising besides, the advantages of houses of refuge at the piers for shipwrecked mariners, and such like. This bridge, we need hardly remind our readers, is designed upon the novel and scientific principle, that if you stretch a single cable as far as it will possibly go without rupture, and then a little further, it will break; but if you put half a dozen such cables together, you obtain an infinitely strong foundation whereon to construct. But Boutet has not yet revealed the secret whereby he stretches cables, not only until they cease to sag, but have a considerable camber.

A New Safety Lamp.—It is half a century or thereabouts since the partisans of Sir Humphey Davy and of George Stephenson disputed as to who was the original inventor of the safety lamp; and during the period which has since elapsed, several alleged improvements, designed to increase its practical utility, have been produced. The most recent of these consists in securing the wire gauze or other casing of the lamp by means of a bolt, catch, pawl, or other similar fastening of iron or steel situated inside the lamp and held in its place by means of a spring. This bolt or catch, on the application of a magnet to the outside of the lamp, will be withdrawn by the attractive power of the magnet, so as to allow of the wire gauze or other casing being removed.

Jacketing Boilers.—One of the latest of the many plans proposed for preventing the radiation of heat from steam boilers consists in applying plaster of Paris by surrounding the vessel or surface to be protected in some cases, wholly or in part, by an envelope of sheet iron, lead, wood, or other suitable material, placing the envelope at a distance apart from the surface equal to the thickness required for the non-conducting material. The plaster of Paris is then made up in its liquid state and run or poured into the space between the envelope and surface of the vessel until the space is filled. The plaster of Paris in a few minutes solidifies without the application of heat, and the envelope may either remain permanently or be removed after the space is filled.

THE HAGAN PROCESS.

From "The American Exchange and Review."

Considerable effort has lately been made to draw attention to a process of disintegration of the gangue ores, particularly the gold-bearing quartz of California, by a process known as the Hagan process. We have gathered from various sources the following statements and descriptions:

This process sets up the claim that through its use practically the entire contents of any gold or silver-bearing ore can be saved and made available.

The method of treatment is as follows: The ore, as it comes from the vein, is broken to battery size before being put in the furnace; and it will be observed that this involves no expense which is not now incident to the common mill process, as all ores must be broken to proper size before being reduced in the battery. When broken as described, the ore is dumped into a furnace built of either stone or brick, whichever may be the cheapest in construction. This furnace is about 4 ft. in diameter of ore chamber, by about 20 ft. in height, a furnace of this size having the capacity of about 20 tons. By the decomposition of superheated steam, a supply of oxygen and hydrogen gases is obtained, and these gases are conducted to the chamber containing the ore, and being brought in contact with the raw ore, they immediately attack the sulphur, arsenic, antimony, or other base materials which may be in the ore and expel them completely, thus removing all obstacles to the amalgation of the precious metal; in short, making the gold that may be in the rock really free gold, which is then as susceptible of amalgamation as ravine gold. The simplest pan process is all that is needed to extract the gold from the ore thus treated, and *all* the gold in the ore is yielded up, the loss being only the inevitable mechanical loss which results from manipulation in the pans.

In the case of silver ores, it is necessary to chlorinize before amalgamation, of course; and it seems remarkable that two such inventions as this Hagan-furnace process and Kustel's chlorination process, the two together seeming to form a complete solution of the great and hitherto unsolved problem of how to work rebellious gold and silver ores, should be announced almost simultaneously.

Of course the practical value of this invention depends very much upon the cost of the process. Regarding this, we learn that so far as the furnace itself is concerned, it is not expensive in construction. In nearly every locality where needed, the materials may be found upon the ground. The points to be sought in the construction are strength and capacity. These may be obtained by the use of either stone or brick. In any ordinary locality a 20-ton furnace ought not to cost, complete, over £2,000; and a furnace of 50 tons' capacity can be bought for less, proportionally, than of smaller size; and the larger the furnace the less will be the expense of treatment of the ore, as the same number of men can attend to either a 20-ton or a 100-ton furnace.

The cost of treatment per ton will be from 50 cents to one dollar and a half, according as 20 or 100 tons are treated at one time. It will be seen, therefore, that even the lowest grades of ore may be profitably treated by this process, and this greatly enhances the value of the discovery.

But still further advantages are said to result. The ore when treated is left in such a friable condition that it is most easily reduced, and the capacity of the battery is more than doubled, so that a five-stamp mill will reduce more of the treated ore than a ten-stamp mill will of raw ore. This advantage will be duly appreciated by those who know the cost of mill machinery; and the benefits do not end here. Not only is the capacity of any mill doubled, but the wear and tear of both stamps and pans is greatly reduced in consequence of the more friable condition of the treated ore. Considering these advantages, it may truthfully be affirmed that there is no additional cost by this process over the common method of milling ores, the gained advantages more than compensating for the cost of the furnace treatment.

It is quite probable that this new method may produce a radical change in the machinery for crushing ores, and make it possible for us to avail ourselves of that most desirable of all forms of ore-crush-

ing, viz., dry-crushing. We only make the suggestion; but if such a thing were possible, the fact would be hailed with satisfaction by practical mill men, who now realize the extent of the loss of precious metal through the wasteful, but seemingly unavoidable, method of wet-crushing.

We will not now enlarge upon this matter, important as it is; but we have said enough to make it apparent that if what is affirmed of this process is true, we have cause for congratulating the public upon a discovery of such vast importance to the world at large. Coming at a time when the yield of the precious metals seems decreasing, and seeming to promise the unlocking of vast stores of hitherto unattainable mineral wealth at a moment when this wealth is most needed, this invention seems a blessing of almost infinite value, and we are sure our readers will unite with us in the wish that all that is claimed for it may be completely realized.

SOMERSET HOUSE ACCIDENT.

[From "Engineering."

The accident at Somerset House—if a catastrophe resulting from the operation of well-known and immutable laws of Nature can fairly be styled an accident—has fortunately afforded a few paragraphs only in the daily press. By good luck, the element of time was involved in the problem of probabilities in the present instance, and the fall of the girders, which was certain to occur sooner or later, took place at the most opportune moment; had the girders kept to their work but five hours longer, the resulting tragedy would have afforded a theme for many articles instead of receiving but the small publicity of a few casual paragraphs.

The whole history of the failure and its origin may be readily explained without diagrams, and with the aid of but few figures. The site of the accident is the east end of the river terrace of Somerset House, and the immediate cause of the same was the fracture of a cast-iron girder, by which an area of about 70 ft. by 25 ft. of the terrace floor was thrown upon and through the floor underneath. Three main girders resting upon piers projecting from the general face of the wall, by which the effective span was reduced from 25 ft. to 19 ft., divided the length of 70 ft. into four bays, and in each of these bays three cross girders, carrying two ring brick arches, with 1 ft. of gravel on the top, were joggled into the main girders, one cross girder occurring at the centre of the span, and the other two at distances of 3 ft. from the respective piers. It was at one of the latter points that the weakness of the structure was first evidenced; the fractured section there disclosed three terrible flaws, as shown on the accompanying cross section, the one on the outer edge of the bottom flange being no less than 11 in. deep. These

flaws were no doubt induced by the vicious form of the casting at the point where the cross girder was dovetailed into the main girder.

We propose in the first place to eliminate the factor of safety provided by the architect of the Somerset House terrace, assuming the castings to have been of

good quality throughout; we shall then ascertain how far the results will be modified by the flaws brought to light by the recent failure.

Referring to the sketch of the girder, it will be seen that at the point of fracture, the form of cross section is a ⊥, the vertical web being 1 ft. 6 in. × 1¾ in. about, and the bottom flange 7½ in. by 1⅝ in. average thickness. Between the cross girders a top flange 3½ in. wide is introduced, but of course this does not affect the strength of the girder as far as the present investigation is concerned. The calculated moment of resistance of the cross section (M) in feet × square inches is M=10.8 for compression, and M=17 for tension. It will, therefore, be necessary to deal with the tensile strains only. The dead load of the superstructure being 2 cwt. per sq. ft., it follows that the load upon the main girders, including the weight of the girders themselves, will resolve itself into 3 weights of 13 tons each —one at the centre of the 19 ft. span, and the others 3 ft. from each bearing. The moment, *m*, of the load at the latter points will of course be *m*=19.5×3=58.5 foot tons, and at the centre an additional amount of 6.5×6.5=42.25 foot tons; hence, at the middle of the span, the point of maximum stress, *m*=100.75. Dividing *m* by M, we get the maximum *apparent* unit strain F, upon the metal, equal to 3.44 tons per sq. in. at points 3 ft. from the bearings of the girder, and to 5.93 tons per sq. in. at the centre of the span. Now the ultimate value of F in cast-iron girders of the form of cross section under consideration may be shown, upon the principles advanced in a previous paper (Strain on Beams, "Engineering," vol. v., p. 390), to be equal to 1.29 times the direct tensile resistance of the material; hence, estimating the latter resistance at the fair amount of 7 tons per sq. in., the ultimate apparent strength of the same iron in the girder form would be 9 tons per sq. in. This result is corroborated by two of Mr. Fairbairn's experiments on precisely similar forms of beams, in which the value of F averaged 9.1 tons per sq. in.

Adopting the preceding value, then, the factor of safety provided in the fractured girders would be 9 tons÷3.44 tons =2.6 at points 3 ft. from the supports, and 9÷5.93=1.5 at the centre of the span —that is to say, even upon the false hypothesis of good iron and sound castings, the girders were loaded up to two-thirds of the breaking weight!

But, as the fracture did not occur at the centre of the girder, but at a point 3 ft. from the support, it is evident that the latter section was relatively the weaker, and it follows as a corollary that the flaws in the casting must have reduced its strength at least 45 per cent. There are no theoretical objections to this conclusion, for it was shown in the pap r already cited that the loss of strength in a flat bottomed rail with a hole on one side of the flange amounted to one-third of the whole, although the loss of sectional area in the bottom member of the girder rail was less than one-sixth of the entire area of the metal in tension. There is nothing surprising, therefore, in finding a loss of 50 per cent. in strength accompanying the loss of 25 per cent. in the area of the bottom flange of the broken cast-iron girder.

The probable loss of strength, on account of the flaws actually measurable, being at least 50 per cent., it follows that the unit strain at the point of fracture could have been no less than 6.88 tons per sq. in., or in round numbers, ⅞ of the ultimate resistance of the iron. Now, Mr. Fairbairn found that a cast-iron bar would sustain a perfectly quiescent load, equal to 95 per cent. of the breaking weight, for some months, before failing, and that when the load was diminished to 75 per cent. the deflection continually increased during the five years of observation, and of course such a phenomenon clearly prognosticated the ultimate failure of the bar. There is nothing illogical, then, in the cast-iron beams of the Somerset House terrace sustaining a load equal to ⅞ of the breaking weight without any signs of weakness even had it been for half a century, and their final failure is but interesting confirmatory evidence of the previously ascertained fact, that, under such conditions, a grand crash must ultimately ensue. We do not know who designed the girders, and we are not sure that he is responsible for the accident. Possibly the imposition of 12 in. of gravel over the tiles covering the jack arches was not contemplated by the designer; if so, we can only hold him responsible for a working load equal to ⅓ of the breaking load; and in instances where dead load alone has to be sustained,

such a margin of strength is quite justifiable. Under the load actually imposed, however, the large dining-hall, 70 ft. by 25 ft., could only be compared to a Brobdignagian mouse-trap, and we care not to dwell upon the calamitous results which would have followed the coming down of the trap had it occurred at feeding time.

The simple facts of the case are, that the girders were carrying two-thirds of their calculated breaking weight, and probably would be carrying the same at the present time, had not the presence of some extensive flaws in one of the girders at a point 3 ft. from the support induced failure at that relatively little strained portion of the girder. The fall of one girder was of course followed by the destruction of the whole. We leave our architectural and building friends to draw their own conclusions.

BURNING POWDERED COAL.

From "The American Artisan."

In the breaking and screening of coal at the mines there is much dust and pulverized material made, for which, in this country at least, little or no use has been found. In England local accumulations of like character, at available points, have been disposed of in the fabrication of so-called "patent fuel," and a product similar to this, made by compressing the dust into blocks with some bituminous substance, has been for some time in use in the boiler furnaces of French steam vessels. With us the numerous projects for making a condensed fuel from the waste have met with little or no favor; possibly because the anthracite dust, to the utilization of which these plans have tended, is less useful for the purpose than that from bituminous coal, but principally because projectors have aimed to manufacture the artificial fuel from the dust collected at the mines, where the best grades of coal for burning can be sold at figures far less than the cost of making the compressed material. The success experienced abroad in making use of refuse, already brought to or near the place of consumption, is, therefore, no parallel to what might reasonably be expected to result from any attempt to make it in direct competition with the coal at the mouth of the pits. It being, therefore, doubtful whether artificial fuel can be profitably made on any extended scale with us, it behooves inventors to seek for some other means of utilizing the immense quantities of dust and refuse now lying useless wherever our great coal-fields are worked. There is good reason to suppose that this may be found in apparatus for burning powdered fuel, which could be obtained as well from the comminuted material adverted to as from that of the larger and usual commercial sizes. Our English exchanges speak of a furnace, of the construction of which we have no detailed description, by which, it is claimed, powdered fuel can be effectually and profitably burned. If in this country any efficient apparatus of the kind has been made, it has not come to our notice. Meanwhile the coal-refuse heaps grow broader and higher, and make more evident the truth that in them is the need of an invention which the boasted ingenuity of American projectors has thus far failed to provide.

Experiments, most of them made abroad, have shown that there are several essentials to any practical means of burning powdered fuel. Provision must be made for the regular supply of the material to the fire-box, and for the adjustment of such supply when desired. The powdered fuel must be very perfectly mingled with air previous to combustion. The arrangement of parts must be such that all resultant slag or cinder may be readily removed. Space must be afforded for the complete combustion of all the particles before the gases make their exit; and the whole construction must be such that no more than average skill and intelligence be required in its management and repair.

Although somewhat formidable in array, none of these requisites appear to be insurmountable. They could, in all probability, be overcome by suitable mechanical appliances, the cost of operating which would be slight in comparison with the advantages which would be gained by their successful application. Theoretically

considered, the uniform feeding of the material, which is mainly interfered with by its damp condition, would be insured by causing it to pass between rollers to a centrifugal distributer, by which the separation of its particles would be very thoroughly secured. From the distributer its passage to the fire-box could be aided by the direct action of an air-blast, which would insure the fulfilment of the second of the conditions previously adverted to. The others, matters more of mechanical judgment than of invention, could undoubtedly be provided for by simple means were the two former effectually met, either in the manner sketched or in a different one.

As to how far such theoretic ideas will apply in practice can, of course, only be found out by careful experiment. It is about time, moreover, in these days of high-priced fuel, that the refuse coal-dust be put to some useful purpose, the most obvious of which is, of course, the generation of steam, although there is no reason why it should not be employed as well in furnaces designed for other functions. It may be remarked, in conclusion, that it is somewhat surprising that so little has been even attempted in utilizing this refuse fuel. The engines of steam sawmills are driven by the combustion of damp sawdust, fed regularly to the boiler furnaces by suitable agitating and feeding devices, and in tanneries the soaked tanbark from the pits is burned in apparatus constructed for the purpose, effecting, even in small establishments, an annual saving of many hundreds of dollars. Success having been obtained with these materials, certainly not less refractory to combustion than coal-dust, there is good reason to suppose that the same result could be readily reached with the latter, were the same degree of attention expended upon it.

THE RESISTANCE OF VESSELS.

From "The Engineer."

At a meeting of the General Committee of the British Association, held at Norwich last year, it was resolved that a committee, consisting of Mr. C. W. Merrifield, F.R.S., Mr. G. P. Bidder, Captain Douglas Galton, F.R.S., Mr. F. Galton, F.R.S., Professor Rankine, F.R.S., and Mr. W. Froude, should be appointed to report on the state of existing knowledge on the Stability, Propulsion, and Sea-going Qualities of Ships, and as to the application which it may be desirable to make to Her Majesty's Government on these subjects. We now subjoin the first report which has been made by this committee, a report the value of which can scarcely be overrated.

FIRST REPORT.

Prepared for the Committee, by Mr C. W. Merrifield.

The subject referred to us is a very large one; and, having regard both to the space which a complete report on such a matter would require, and to the time at our disposal for making it, we have thought it best to lay before the present meeting a first report, in which we confine ourselves to the *resistance which ships offer to propulsion*, and to their *behavior in respect to rolling*. These are, in their several directions, the preliminary subjects necessary to the inquiry committed to us; and they are also the parts of naval science on which exact experiment appears to be most urgently needed, both for the direct knowledge of these branches, and also as a foundation for experiments on propulsion and the other applications which depend upon them. Knowledge of the work to be done should precede the selection of the tool with which it is to be performed.

RESISTANCE.

Total Resistance.—The question of resistance may be treated in two ways—either in gross, as regards the power required to drive a vessel of certain form and dimensions at a specified rate; or, in detail, as regards the exact way in which the vessel and the propeller act and react upon the water which they disturb. Hitherto there has been but little connection established between the phenomena of detail and the general result, the former not being understood with any reasonable degree of certainty, and the latter also being far from settled with precision.

The variable elements which go to make the resistance what it is, are chiefly velocity, form, condition of surface, and absolute dimension. The effect of form is as varied as the number of forms which can be given to a floating body. As regards dimension, assuming the forms to be diametrically the same, it has been found that vessels of different absolute size do not correspond in the degree of resistance which they encounter, whether in smooth water or in waves. It will also be seen that the absolute length of a ship, considered irrespectively of breadth or depth, has a direct influence on the resistance.

As regards velocity, it is usual to assume, in books on hydrodynamics, that the resistance of water varies as the square of the speed. For the purposes of naval architecture, this can only be taken to be roughly true under certain limiting conditions, beyond which the law of the squares deviates widely from the observed facts. It appears to be probable that this increase, as the square of the speed, is rather a minimum than a general rule of increase ; and that such a minimum is only attained by ships of good form, and of a length which is a certain function of the speed. The vague words, *good form*, are used designedly ; it being still uncertain what the best form may be, and what extent of deviation from it takes the vessel out of its operation. When the vessel is shorter than a certain limit of length depending on the velocity, the resistance seems to increase more rapidly than the square, and the power needed to drive the ship consequently increases faster than the cube of the velocity.

It may save confusion to remark that the measure of *resistance* is referred to a a unit of distance, while *power* is referred to a unit of time. For any law of resistance, therefore, the power varies as the product of the resistance and speed, and where the velocity varies, we have simply to use the corresponding integral formula.

As already remarked, the *leading formulæ* of the resistance to water are :

$$R \propto V^2, \; HP \propto R\,V \propto V^3,$$

the latter being the strictly necessary consequence of the former. There is but little disagreement among writers up to this point. But the moment we attempt either to assign values to the constants of the equations which they imply, or to introduce the corrections depending on the complex phenomena, which always, more or less, mask the mere question of fluid resistance, we find very little agreement.

The chief elements of the resistance of water to a body moving through it are:

1. The *direct head resistance*, due to the work of thrusting the water to the right or left, with or without vertical motion, in order to make way for the body to pass.

2. The *skin resistance*, or friction of the water on the surface of the moving body, combined with the effect of surface eddies and other minute phenomena.

3. The *back pressure*, due to the diminished pressure in rear of the moving body and in wake of any corners or unfairness of surface which may cause eddies.

4. In addition to these, there are the phenomena of capillarity and of the viscosity of water. These are of importance as regards minute bodies, including even small models. But for large ships, they are sufficiently accounted for in the arbitrary constant of skin resistance. This fourth head may, therefore, be neglected, except when we wish to pass from ships to models.

For extreme shapes it does not appear that the three leading elements of resistance can be grouped under one term. But there is reason to believe that, for vessels of a certain form, they all involve, with a respectable degree of approximation, the square of the velocity, and also that the forms for which this is true are among those which offer, *cæteris paribus*, the least resistance. Under these circumstances, the formulæ depending on skin resistance may be made to include the other two by merely altering the constants. We conjecture that, when authors state that certain elements of the resistance may practically be neglected, they usually mean that they can be accounted for in assigning the values to the arbitrary constants, which, in any case, must be determined from experiment. We have named vessels *of a certain form* ; this form must be regarded as still unknown, except with reference to some limitations of a negative character, even these being rather indefinite. They include a fine entrance and a fine run, and an absolute length of not less than the length of the trochoidal wave moving with the same velocity. The

actual determination of the form of least resistance is not only unsolved, but the data of the problem are yet unknown.

The first formulæ that occur are the well-known coefficients of steam-ship performance:

$$\frac{(\text{Speed})^3 \times (\text{displacement})^{\frac{2}{3}}}{\text{Indicated horse power.}}$$

$$\frac{(\text{Speed})^3 \times \text{area of midship section}}{\text{Indicated horse power.}}$$

As affording a rough measure of comparison, the tabulation of these formulæ for different ships is extremely convenient. But they are of very little assistance in settling a theory. Even for the same vessel, tried under apparently similar conditions, these coefficients do not appear to be constant quantities. Moreover, the varying efficiency of the steam-engine and of the propeller, considered as machines for the transmission of power, are inseparably grouped with the work of overcoming resistance. When the consumption of coal is substituted for the I.HP., the efficiency of the furnace and boiler also comes in. Some of these remarks apply to Mr. Hawksley's approximate formula:

Velocity in statute miles=27.

$$27\left(\frac{\text{effective horse power}}{\text{wetted surface in } \square'}\right)^{\frac{1}{3}}.$$

But this was only intended for rough purposes.

We may here mention a formula given by Mr. Greene, in a paper read at the Franklin Institute of New York, and reprinted in the "Mechanics' Magazine" for 8th July, 1864. It proceeds on the assumption that the power expended in overcoming back pressure and friction in the engine varies directly as the speed:

$$\text{HP.} = D^{\frac{2}{3}} V (.1552 \times .0046846\, V^2),$$

the constants being obtained empirically.

Most modern formulæ for resistance take account of the form of the vessel, in such a manner as to require the use of the drawings of the exterior surface of the ship. The Swede, Chapman, in his well-known treatise on shipbuilding, assumes that the surface of the vessel may be divided into small portions, the resistance of each of which will be proportional to its area, to the sine squared of the inclination, and to the square of the velocity; with a certain small correction on account of the currents which are set up by the ship's own motion, and which modify the pressures. But he himself saw reason from subsequent experiments to doubt whether the law of the sine squared, or even that of the velocity squared, was applicable to the forms which he used.

Euler,* and most of the older writers use the sine squared of the inclination, as the factor representing the effect of obliquity; and this theory has been revived by Mr. Hawksley, in a discussion at the Institution of Civil Engineers, reported in their Proceedings for 1856, vol. xvi., p. 356. But we think that there is now ample experimental ground for believing that, whether or not this law be true with respect to an infinitesimal portion of a plane receiving the impact of a thin jet of water, it is not true either of plane surfaces of considerable extent, or, as a differential formula, of curved surfaces. It evidently fails to take account of the effect of the stream which is set up along the surface in deflecting the impact of water on the part of the surface further back from the entrance. The assumption that this has no effect is not one which can be admitted without proof; and the experimental evidence tends the other way. Chapman's later experiments, the experiments of the French Academy, and those of Colonel Beaufoy,† are all against the hypothesis of the sine squared of the inclination. The supposition that the sine squared of the inclination represents the effect of the obliquity of the after-body is still more open to doubt than when it is applied to the fore-body.

As a contribution to the history of the subject, the following translation from a tract of M. Dupuy de Lôme will be interesting:

Romme, in his Memoir for the Academy of Sciences, in 1784, while giving an account of the experiments made by him at Rochefort on models of ships, one of which represented a 74, and again, in his work on the "Art de la Marine," had very succinctly laid down that this resistance was

* See his "Scientia Navalis" (St. Petersburgh, 1749), vol. i., p. 213. See also D'Alembert, "Traité de l'Equilibre et du Mouvement des Fluides." Ed. of 1770, p. 226.

† See Chapman (by Inman), p. 257; Bossut, "Hydrodynamique," vol. ii., p. 396; Beaufoy, p. 87. See also Scott Russell's "Naval Architecture," p. 168; or "Proceedings of Civil Engineers," vol. xxiii., p. 346, as to the French experiments.

independent of form. "Provided," he went on to say, "the water-lines have a regular, fair curvature, as is the case in modern vessels, the greater or less fulness of the bow or stern neither increases nor diminishes the resistance of the water to their progress."

In direct contradiction to this too summary rule, which has long obstructed the progress of naval architecture, my experience leads to five principles, which I state as follows:

1st. Among vessels of similar geometrical form, of different size, but all having their immersed surface exceedingly smooth and driven at the same speed, the pressure needed to attain this speed increases more slowly than the surface of the greatest transverse section. It is near the truth to say, that, for similar forms, the resistance per square metre of midship section, at the same speed, decreases as the vessel increases, in the ratio of the square roots of the radii of curvature of its lines, these radii being themselves proportional to the linear dimensions of the ships; it is, therefore, wrong to compare the resistance of different ships by means of experiments made on models to reduced scales.*

2d. If the same vessel be driven at different speeds, the force needed to obtain these velocities increases less rapidly than the square of the speed, while that is small. The force increases as the square for ordinary rates of 3 to 5 metres per second, according to the condition of the surface in respect of smoothness. Beyond that speed, it increases faster than the square.†

3d. The diminution of the angle of entrance, and the lengthening of the radius of curvature of the lines which the water has to follow, especially in the replacement in wake of the stern by the water coming up from below, are the principal means of diminishing the resistance. This has the greater influence, the greater the driving power. For very slow motion, the influence of form is less than that of surface friction.

4th. The sharpness of the bow, both above and below the water line, which has in calm water the effect just mentioned, has more marked advantages in a heavy sea-way.

5th. The smoothness of the wetted surface plays a considerable part in the resistance; and this part, due to friction, varies but little with the speed.

I add that the resistance of the hull increases markedly in narrow channels, and still more where the depth of water does not much exceed the draught of the ship; so that experiments ought to be made in deep water.

Finally, my numerous observations on the resistance of ships, in calm weather and open sea, agree, with a close approach to exactness, with the following formula, which I have since adopted as the measure of the resistance:

$$R = K S (V^2 + 0.145 V^3) + K^1 S^1 (V)^{\frac{1}{2}}.$$

In this formula, I call—

S, the area of midship section in square inches.

S^1, the product of the mean girth (wetted) into the extreme length, also in square mètres.

V, the speed in mètres per second.

K, a coefficient varying with the form, diminishing inversely as the square root of the radii of curvature of the longitudinal sections, and also diminishing with the mean angle of entrance. This second reduction amounts to about 15 per cent., as the mean angle of entrance comes down from 45 deg. to 15 deg. It is, therefore, about one-half per cent. for each degree between those limits.

K^1, a coefficient independent of the form, and varying only with the smoothness of the wet skin. This coefficient can increase in the ratio of 1 to 10, from 0.3 for bottoms very smoothly covered with good copper, and the heads of the nails well beaten down, to 3.0 for hulls covered with weed and barnacles.

R is the resistance expressed in kilogrammes, and corresponding to the speed V.

For each ship experimented upon, two trials are sufficient to determine K and K^1.

For the Napoléon, while clean, the cop-

* M. Reech, Director of the "Ecole d'Application du Génie Maritime," has long since pointed out in his lectures the error frequently made of comparing the resistance of vessels of various forms by means of experiments upon models driven at the speed proper to the vessels themselves.

† I am here speaking of vessels only partially immersed, not of vessels which are entirely under water.

per being oxidized, not greased, I found

$$K = 1.96 \qquad K^1 = 0.44,$$

from which I obtain for the general expression for the resistance to the passage of the ship through the water:

$$R = 1.96\,S\,(V^2 + 0.145\,V^3) + 0.440\,S^1\,(V)^{\frac{1}{2}}.$$

A table previously given shows that during the trial trip of the Napoléon, the values of S and S^1 were:

S between 99 and 1000 square metrès.
S^1 between 1580 and 1610 square métres.

* * * *

The power needed to obtain this speed is obtained from this calculation by multiplying the resistance, so calculated, by the velocity.

The above remarks are translated from a Memoir published by M. Dupuy de Lôme on the occasion of his candidateship for the French Academy in 1865–6. It is reprinted in M. Flachat's "Navigation à Vapeur Transocéanienne," vol. i., p. 206.

It may not be out of place to mention, in explanation of M. Dupuy de Lôme's remarks about the angle of entrance, that the architects of the Imperial Navy avoid the use of the hollow bow. There is at most a slight concavity at the forefoot. Hence the angle of entrance has a meaning which is sometimes lost in modern English practice.

M. Bourgois, in his Memoir* on the "Resistance of Water," gives formulæ which may be grouped under the general form of

$$R = B^2\,V^2\left(K_1 + K_2\frac{l\,V^2}{B^2} + K_3\frac{S}{B^2\,V}\right),$$

B^2 being the area of midship section, S the wet surface, and l the breadth extreme. K_1, K_2, and K_3 are constants which vary with different classes of vessels.

The dependence of the resistance of ships upon the theory of waves appears to have been first insisted upon by Mr. Scott Russell. That gentleman seems to have been the first to discover that there was a relation between the length of the ship and the velocity of advantageous propulsion, this relation being taken directly from the theories of the solitary and of the trochoidal waves. We will state his theory of resistance in as few words as possible:

Scott Russell's Theory of the Form of Least Resistance.

A vessel may be divided longitudinally into three portions, bow, straight middle body (if any), and after body. The midship section may be of any shape whatever, the resistance due to it depending on its area and wet girth only. The fore body must have for its level sections curves of sines (harmonic curves) whose equation may be written as

$$x = \frac{l\,\theta}{\pi},\ y = \tfrac{1}{2}b\,(1 + \cos.\ \theta),$$

b, being the half breadth of the ship at any level, and l the length of the fore body, which must not be less than the length of the "solitary wave," which has the same speed as the ship is intended to have, in order that the resistance may be the least possible. The after body is to have trochoids for its level lines, their equation being

$$x = \frac{l^1\,\theta}{\pi} + \tfrac{1}{2}\,b\sin\theta,\ y = \tfrac{1}{2}\,b\,(1 + \cos.\ \theta),$$

l^1 being the length of the after body, which is not to be less than that of one-half of the oscillating or trochoidal wave of the same speed as the ship. The straight middle body may be of any length whatever, as it will only affect the resistance by increasing the surface for friction; or, subject to these conditions, the resistance of the ship will be expressed by

$$(K \oplus + K^1\,S)\,V^2,$$

where $\oplus$ represents the area of midship section, and S the wetted surface. K and K^1 are coefficients, the former of which may be roughly stated at $\frac{1}{10}$ of that due to a flat plate drawn flatwise through the water, and the latter depending upon the condition of the surface. For a pure wedge bow, whose angle is ε, Mr. Scott Russell considers that the resistance varies as $\left(\frac{\pi}{2\pi - \varepsilon}\right)^2 - \varepsilon$ lying between the limits of 12 deg. and 144 deg.; and where the bow is compounded of this and of the wave form, he gives as a rough measure of the resistance, a formula obtained by compounding this, in such proportion as may properly represent the geometrical combination of form, with the resistance due to the wave form.

* Published at Paris, by Arthur Bertrand. See also Sonnet, "Dictionnaire des Mathematiques Appliquées," Art. "Résistance des Fluides."

As far as can be judged by Mr. Scott Russell's published writings, there appears to be some unsettled ground in his theory relatively to the shape of the after body. The form of the bow is simply that of one-half the profile of a solitary wave of translation, laid horizontally instead of vertically. The form of the stern is also taken from the form of the wave, which is set up when a hollow in the surface of water has to be filled up; but it is nowhere made clear whether this form ought to be given to the level sections, or to the vertical longitudinal sections, or whether some compromise should be made between the two; and it seems probable that the author himself was doubtful on the subject. The experiments recently made under the direction of the Committee of the British Association appointed to make experiments on the difference between the resistance of water to floating and immersed bodies (Report for 1166, p. 148), seem to indicate that that doubt is still unsettled.

Without hazarding an opinion as to whether this form is really that of least resistance, it appears certain that the curves used are among those along which fluid particles can glide smoothly, without causing supernumerary diverging waves in the liquid.

The general formula for the length of a ship given by this theory is:

Fore body in feet $= \frac{2}{g}\pi V^2$ in feet per second.

After body $= \frac{2}{3}$ fore body.

The following are the values of the factor and its logarithm, which give the length of the fore body in feet, when the velocity is given in

Feet per second....	0.19,518	log. = 9.29045.
Knots per hour	0. 5,561	log. = 9.74515.
Statute miles per hour.....	0.41,985	log. = 9.62310.

Professor Rankine states, as the result of his own observation, that it is possible to shorten the bow to two-thirds of the length given by this formula, without materially increasing the resistance; but that it is very disadvantageous to shorten the after body.

In the "Proceedings of the Civil Engineers," vol. xxiii. (for 1864), p. 321, is a paper by Mr. G. H. Phipps, on the "Resistance of Bodies passing through the Water." Mr. Phipps considers that the total resistance may be subdivided as follows, into additive parts:

Head resistance—varying directly as the midship section, and inversely as the square of the projection ratio of the bow.

Stern resistance—a similar function for the stern.

Friction resistance—varying directly as the surface immersed.

Additional head resistance—an empirical correction assumed to be a function of the immersed surface, and of the draught of water.

The sum of these resistances is then multiplied by the square of the velocity.

The paper was followed by a discussion, in which most of the leading English writers on Fluid Resistance took part. The paper and discussion thus constitute a very fair *résumé* of the opinions then held on the subject in this country.

Mr. Phipps considers that the coefficient of friction of water on the outer surface of a vessel is less than on the inner surface of a pipe; and this is, to a certain extent, in accordance with the experiments of Darcy on the friction of water in pipes, which led to the conclusion that the coefficient of friction consists of two terms—one constant, and the other varying inversely as the diameter of the pipe.

Mr. John J. Thornycroft, C.E., in a paper read before the Institution of Naval Architects this year, and which will appear in their forthcoming volume of "Transactions," gives the following formula, the form of which is derived from experiments on the flow of water in pipes:

$$\text{I.HP.} = Vh\left\{ S f \frac{3n}{2n+l} V^{1.7} + \phi S.C. \frac{n\frac{1}{6}+3}{l^{\frac{1}{6}}+3} V^{2.7} \right\}$$

Where S = the wetted surface.
V = the velocity in knots.
l = length.

h, f, n, C, are constants empirically determined.

$\log. h = \overline{3}.65450$
$\log. f = \overline{2}.10170$
$\log. C = \overline{2}.0041$
$n = 380$

$$\phi S = f (\sin \theta)^{2.5} ds,$$

$d s$ representing an elementary portion of the surface, S, and θ the angle which this portion of the surface makes with the line of motion. It will be noticed that the formula involves a large number of constants, more or less arbitrarily determined.

Professor Rankine, in a paper in the "Transactions of the Institution of Naval

Architects" for 1864 (the substance of which is repeated in a treatise on "Shipbuilding: Theoretical and Practical"), states that the processes amongst the particles of water through which resistances to the ship's motion may be caused indirectly, may be thus enumerated:

1. The distortion of the particles of water.
2. The production of currents.
3. The production of waves.
4. The production of frictional eddies.

The first cause he regards as having no appreciable effect on actual ships, although possibly sensible in small models. Of the second cause (the production of currents), Professor Rankine remarks, that it "never acts upon a well-designed ship; for such a ship is so formed that the particles of water glide over her surface throughout its whole length, and are left behind her with no more motion than such as is unavoidably impressed upon them through adhesion and stiffness; and hence the failure of the earlier theories of the resistance of ships, which were founded on experiments made with flat plates, wedges, and blocks of *unfair* shapes.

Dr. Rankine then gives a detailed account of the waves which accompany a vessel driven at a speed greater than the limit to which she is properly adapted, showing that they diverge from the course of the vessel, at an angle depending on the proportion in which their speed of advance is less than her speed, and thus carry off energy, which is lost; and he proceeds to state: "The conclusion to be drawn from these principles is, that for each vessel there is a certain limit of speed, below which the resistance due to the production of waves is insensible; and that as soon as that limit is exceeded, that resistance begins to act, and increases at a very rapid rate with the excess of speed." "Through the discoveries of Mr. Scott Russell, a vessel can be designed in which this kind of resistance shall be insensible up to a given limit of speed; and therefore, the resistance due to waves has no sensible action on a well-formed ship." These remarks, of course, apply only to waves formed by the ship, and not to sea waves which she may have to encounter.

"The resistance due to frictional eddies thus remains alone to be considered. That resistance is a combination of the direct and indirect effects of the adhesion between the skin of the ship and the particles of water which glide over it; which adhesion, together with the stiffness of the water, occasions the productions of a vast number of small whirls or eddies, in the layer of water immediately adjoining the ship's surface." Instead of assuming that the frictional resistance is simply proportional to the actual immersed surface, Dr. Rankine uses what he calls the *augmented surface*, which is obtained by multiplying each infinitesimal element of the surface by the cube of the ratio which the velocity of the gliding of the water over that portion bears to the speed of the ship, and summing them. Let s be the actual surface, and q the velocity ratio of gliding; then the augmented surface is $\int q^3 \, d\, s$; and if, further, V be the speed, g, gravity, w, the heaviness of water, and f, the coefficient of friction, then

$$\text{Eddy resistance} = \mathrm{V}^4 f \frac{w}{2g} \int q^2 d\, s.$$

Taking the cubic foot as the unit $\frac{w}{2g}$ does not differ much from unity for sea water, and the formula thus reduces to $\mathrm{V}^2 f \int q^3 \, d\, s$.

It is, of course, impossible to calculate $\int q^3 \, d\, s$ in detail for every ship; and it therefore becomes necessary to find some auxiliary formula. In the "Philosophical Transactions" for 1863, pp. 134–7, Mr. Rankine has shown that the augmented surface of a trochoidal riband on a given base and of given breadth may be found by multiplying their product by the following coefficient of augmentation:

$$1 + 4\,(\sin\phi)^2 + (\sin\phi)^4$$

in which ϕ is the angle which the inflexional tangent makes with the base. For a ship in which the stream-lines or tracks of the particles of water are trochoids, it would be a sufficient approximation to integrate—

$$\text{length} \times \tfrac{1}{3}\,\text{breadth} \times \left\{1 + 4\,(\sin\phi)^2 + (\sin\phi)^4\right\}$$

with regard to the draught of water, considering both the angle ϕ and the half breadths as variable elements to be determined from the drawings. Where the stream-lines are not trochoids, ϕ may be taken as the angle of greatest obliquity. But the theory has been only partially extended to three dimensions; and indeed, if it were possible to do so, the mere introduction of a third variable would not meet

the case unless account were taken of the vertical displacement of the surface of the water, consequent upon the uniformity of pressure at that surface.

The resistance determined by the calculation of the augmented surface includes in one quantity both the direct adhesive action of the water on the ship's skin, and the indirect action through increase of the pressure at the bow and diminution of the pressure at the stern.

For the coefficient of friction, Professor Rankine takes f=0.0036 for surfaces of clean painted iron. This is the constant part of the expression deduced by Prof. Weisbach from experiments on the flow of water in pipes. The corresponding coefficient deduced from Darcy's experiments is 0.004.

The augmented surface in square feet, multiplied by the cube of the speed in knots, and divided by the I.HP., gives *Rankine's coefficient of propulsion*. In good clean iron vessels, this ranges about 20,000; while in H. M. yacht, Victoria and Albert (copper sheathed), it reached 21,800. Its falling much below 20,000 is considered to indicate that there is some fault either in the ship, or in her engines or propeller; or else that the vessel is driven at a speed for which she is not adapted.

Professor Rankine adds, that "as for misshapen and ill-proportioned vessels, there does not exist any theory capable of giving their resistance by previous computation."

This again raises the question: What are *good* forms? According to Professor Rankine's theory, they are forms along which a particle of water can glide smoothly. Among these, as a particular case, Mr. Scott Russell's wave lines appear to be included. But these are by no means the only ones which satisfy the problem of smooth gliding, or of streamlines. Another method of constructing curves fulfilling this condition has been given by Dr. Rankine in a series of papers published respectively in the "Philosophical Transactions" for 1863, p. 369, and in the "Philosophical Magazine" for October, 1864, and January, 1865. Elementary descriptions of this method are given in "The Engineer" of the 16th October, 1868, and in a treatise on "Shipbuilding: Theoretical and Practical." Their theory has not yet been carried very far, and when we have reference to three dimensions, it does not appear that any specific mathematical form is to be preferred in respect of its total resistance to a long, fine, fair ship, either drawn or modelled by eye, by a practised draughtsman or modeller.

A possible connection between the resistance of ships and their depths of immersion has been pointed out by Dr. Rankine in some papers published in the "Proceedings of the Royal Society" for 1868, p. 344; in the "Reports of the British Association" for 1868; in the "Transactions of the Institution of Naval Architects" for 1868; and in "The Engineer" of the 28th August, and 30th October, 1868. He shows from theory, corroborated by his own observations, and by those of Mr. John Inglis, Jr., that every ship is accompanied by waves, whose velocity of advance is $\sqrt{g\,k}$, g being gravity and k the *mean depth of immersion*, found by dividing the displacement by the area of water-section. So long as the speed does not exceed $\sqrt{g\,k}$, these waves cannot produce any additional resistance; but when the speed exceeds that limit, the waves are made to diverge from the ship at the angle whose cosine is $\frac{\sqrt{g\,k}}{\text{speed}}$, and thus to carry away energy, like the other diverging waves previously mentioned.

The form of the midship section does not appear to exercise any influence on the resistance to propulsion in still water, except so far as it affects the extent of wetted surface exposed to the action of the water. If the wet girth and the breadth at the water-line be given, the form of greatest area will be a segment of a circle; but this will not be the solution of the question which usually presents itself, namely, given the breadth and the draught required, the form for which the ratio of area to surface shall be the greatest possible. In the particular case in which the draught is half the breadth, it is easily seen that the ratio of area to girth is the same for a semicircular as for a rectangular section, and, therefore, that the solution lies between these extreme cases. It does not appear that the general problem has yet been solved, and, perhaps, as the really practical problem relates to the ship and not to the midship section, it is of secondary interest. A restricted solution

has been given by Mr. James Robert Napier, in a paper read before the Glasgow Philosophical Society, and reprinted in the "Mechanics' Magazine" for 24th April, 1863, vol. ix., page 311, and in "The Engineer" for 1st of May, 1863, vol. xv., page 245.

The best ratio for good propulsion of length to breadth and draught, even when it is assumed that the length exceeds Scott Russell's limits, is not yet known. This is not, perhaps, of practical importance, inasmuch as considerations of economy, capacity, and handiness, generally settle these proportions, without much reference to a theoretical maximum of efficient propulsion. But the extent to which an increase of breadth or depth, leaving other things unaltered, affects the propulsion itself, can hardly be regarded as within our settled knowledge.

The resistance of the air to a ship's hull is not a point to be neglected in practice or in experiment, but it is not one which we propose to discuss here.

The above contains an abstract of nearly all that is known concerning the *total resistance* of a ship in smooth and deep water. We do not consider it necessary in this report to enter into the question of the increased resistances due to shallow water, narrow channels, or a rough sea. We may sum up the result in the broad statement that there exists no generally recognized theory or rule for calculating the resistance of a ship. Many such rules have been put forth, but they do not agree in their form or in their result, and the credit of each consequently rests, as a practical matter, on the reputation of its author.

RESISTANCE CONSIDERED IN DETAIL.

It cannot be said that our knowledge of the detailed phenomena which accompany the motion of a floating body through the water, extends far below the surface of the liquid. Meanwhile the following things appear to be known.

For any vessel driven through the water by any power which does not react on the fluid, there must be a certain movement of the surrounding liquid, chiefly in the direction of the vessel's motion, which shall be sufficient to absorb the work done by the propelling force; for this is really nothing else than the work done by the power in overcoming the resistance. Much of this is masked by oscillatory movement. Now the setting up of an oscillation involves an expenditure of work; but the maintenance of the oscillation once established, is independent of the force which caused it, to just the same extent that it takes work to set a pendulum swinging, but once set going, the continuance does not depend on the starting force. It follows, that making a wave takes up propelling work; but that a wave once started maintains itself or dies out, as the case may be, independently of the propeller, which it can only affect by getting in its way.

In a vessel of good form thrust through a fluid, we first meet with a head pressure which relieves itself by the formation of a head swell, which disperses itself all round if time be allowed for it, either by the sharpness of the vessel's entrance, or by a slow rate of advance. This fixes a limit of speed, which cannot be advantageously exceeded, dependent on the length of entrance as well as on its form—on the length alone, if the form fulfil certain conditions. If the vessel be pushed beyond the speed of dispersion of this wave, it has to be pushed up hill, at a loss of useful work.

The frictional resistance of the surface of the ship also carries a stream of water in the sense of the ship's motion. In fact, nearly the whole work of friction is expended on producing this stream, which forms a part of the ship's wake.

The necessity of filling up the vacuum, which would otherwise be left in rear of the ship, also produces a following stream, accompanied with waves.

In vessels driven at a speed beyond what is suited to their form and dimensions, there are also supernumerary waves, an accunt of which will be found in Profesor Rankine's writings, already referred to.

In vessels of unfair form there will further be violent eddies or whirlpools, as well as extra waves. Seeing that it takes an expenditure of work to make these, it is clear that least resistance means least disturbance. In reality, very little is known about these eddies. Their surface action has been observed, and may easily be seen in dirty water, with froth especially; but their extent in depth, and their amplitude as the depth increases, are utterly unknown; and the other phenomena are not sufficiently well understood to admit of

the effect of these being got at by exhaustion, that is to say, by being equated to the unexplained residue from the effects of the other known causes. Very little, again, is known about the direction in which the replacement aft takes place. The water may, of course, pour in either laterally or from behind, or it may well up from underneath as a wave, more or less; it probably does all three, and the proportion in which it does each is among the things which neither experiment nor theory has yet revealed.

Theoretically, it is of no importance whether we consider the ship in motion and the water at rest, or the ship at rest and the water in motion in an opposite direction. Practically, the conditions are modified by the consideration that a stream of water almost always has a sloping surface, in which case a resolved part of gravity is one of the active forces. Besides this, streams useful for experiment are restricted in depth and width, and the conditions of narrow and shallow channels introduce foreign considerations of a very complicate character.

PROPULSION.

We do not consider advisable in the present report to enter into the question of propellers, except so far as may be necessary to the choice of experiments.

All propellers except sails, tow ropes, and punt poles, do their work by the reaction arising from their driving a stream of water in the opposite direction to the ship's motion, or to their stopping or reversing streams already flowing in that direction. This is the case with oars, paddle wheels, screws, and water jets alike. But, while they thus have one principal action in common, they are only different in their detailed effect upon the currents and waves which accompany the ship, and in the way in which these currents and waves react upon them. Thus, the oars of a row boat send two streams aft, at such a distance from the sides of the boat as to interfere very little with, and to be very little interfered with by, the waves and eddies due to the boat's motion. In the screw propeller, on the other hand, a large proportion of the wake current is either stopped or reversed by the action of the screw, which also interferes with, and is itself reacted upon by, the wave of replacement. These interferences are so large in amount as not unfrequently to mask the whole of the *slip*, from the reaction of which the propulsion is obtained, giving rise to the phenomenon of *apparent negative slip*. For a theoretical account of what is supposed to take place under these circumstances, we refer to the following papers in the "Transactions of the Institution of Naval Architects," and the discussions which took place upon them:

Rankine—"On the Mechanical Principles of the Action of Propellers."

Froude—Note on the above paper, vol. vi. for 1865, p. 13, *et seq.*

Reed—"On cases of Apparent Negative Slip," vol. vii. for 1866, p. 114, *et seq.*

Rankine—"On Apparent Negative Slip."

Froude—On the same.

Rigg—"On the Relations of the Screw to its Reverse Currents." vol. viii. for 1867, p. 68, *et seq.*

Rigg—"On the Reverse Currents and Slip of Screw Propellers." vol. ix. for 1868, p. 184.

See also Bourne—"On the Screw Propeller," second edition, chapter iii., and Rankine—"Shipbuilding: Theoretical and Practical," pp. 88, 89, and pp. 247, 259.

We consider it to be beyond doubt that the theoretical investigations of this part of the subject have been extended in advance of the point at which fresh experimental foundations ought to be laid for them.

FORMER EXPERIMENTS ON RESISTANCE.

The first important experiments were those made by Bossut, Condorcet, and D'Alembert, by direction of Turgot. The results were published as a separate work in 1777, and a very full abstract of them is given by Bossut in his "Hydrodynamique." The chief results are summarized by Bossut as follows:

That the resistance of the same body at different speeds, whatever be its shape, varies very nearly as the square of the speed.

That the direct head resistance of a plane surface is sensibly proportional, at the same speed, to the area of the surface.

That the measure of the direct resistance of a plane surface is the weight of a fluid column which has that surface for

its base, and whose height is that due to the velocity.

That the resistance to oblique motion, other things being alike, does not diminish by a law at all approaching that of the squares of the sines of angles of incidence, so that for sharp entrances, at least, the former theory must be completely abandoned.

Mr. Scott Russell has remarked that between certain limits the observed resistances of wedge bows could be represented with a close degree of approximation, by a formula of the form,

$$R = K\left(\frac{\pi}{2\pi - \varepsilon}\right)^2,$$

where K is a constant, π stands for 180 degs., and ε is the angle of the wedge, which is supposed to be of not less than 12 degs., and not more than 144 degs. See his "Naval Architecture," page 168, and "Transactions of the Institution of Civil Engineers," vol. xxiii., page 346.

The next experiments of importance are those of De Chapman, published in his "Architectura Navalis Mercatoria." The result of those has already been mentioned. He performed some fresh experiments at Carlscrona, in 1795, which seemed to lead to somewhat different conclusions. See Inman's Translation of De Chapman, page 41 and page 257.

We then come to Beaufoy's experiments in the Greenland Dock from 1794–1798. This enormous serious of experiments can only be regarded as establishing very few facts, among which we may mention:

That the resistance to oblique surfaces does not vary as the sine squared of the angle of incidence.

That for *unfair* bodies, such as he experimented upon, the resistance increases faster than the square of the velocity.

That increase of length, within certain limits, has a tendency to decrease resistance.

That friction of the wetted surface enters largely into the resistance.

That friction of the wetted surface appeared to increase in a ratio somewhat less than that of the velocity squared—between $v^{1.7}$ and $v^{1.8}$.

He also arrived at the conclusion that bodies immersed to a depth of 6 ft. experience less resistance than at the surface, but in the case of an iron plane towed flatwise, he found that the resistance increased with the depression.

The whole of these experiments lose much of their value from having been tried on small models, and on bodies which are not ship-shape.

The "Philosophical Transactions" for 1828 contain an account of experiments performed by Mr. James Walker in the East India Import Dock. A bluff bowed boat was towed across the dock by a rope and winch, worked by laborers, the rope being fast to a spring weighing machine on board the boat. The boats tried were of somewhat bluff form, and it was found that the resistance varied only roughly as the velocity squared, increasing faster than that at high speeds. The drawings of the boats are not given with all the detail that could be desired, nor is the condition of their surface minutely described. But the experiment was in the right direction, being upon actual boats meant for use, and of a size far exceeding the models of previous experimenters.

Some experiments by Mr. Colthurst both on the forms of floating bodies as affecting their resistance to motion, and on the friction of wetted surfaces, are given at p. 339 of vol. xxiii., of the "Institution of Civil Engineers' Transactions."

We also refer to the Report of the Committee appointed by the British Association, upon the comparative resistance of bodies wholly and partially immersed (B. A. Reports, vol. for 1866, p. 148). That Committee decided to print the observed facts without any deductions. It is not necessary to the purposes of this Report that we should discuss them. We have already alluded to the difficulty which they indicate as being felt, with respect to the way in which the water of replacement flows in at the stern.

We will next refer to the experiments of Captain Bourgois, which were begun at Indret, in 1844. He first had several boats from 22 to 25 ft. long towed by the Pelican steamer, then under his orders, and later a small merchant schooner of a little over 60 ft. long—and afterwards the Fabert, a brig 98 ft. long. These vessels were simply towed, and their actual resistances measured with a traction dynamometer. Similar experiments have also been tried in France with the screw steamer Sphinx,

109 ft. long; with the screw despatch boat Marceau, 131 ft. long (with its screw on deck), and with the 74-gun ship Duperré, 180 ft. long, built by Sané. Probably, nothing could be better than the experiments thus made, and it is from these that M. Bourgois has derived the coefficients of the formulæ which he has given. But, unfortunately, the particulars of the ships experimented upon are not given in great detail, nor are their drawings published. The only particulars given are the length and breadth on the water-line, the draught, and the area of midship section immersed; but without wet surface, or even displacement.

M. Bourgois's memoir has no date; but it is evidently later than 1843, since he mentions that as the date of an experiment. It also contains some results of trials of propellers set to work against a dynamometer with the vessel made fast, and some trials depending upon the measurement of the power exerted by the engine. But we do not propose to discuss the trials on steam-ship performance. Not only is this the work of another committee, but, inasmuch as they introduce the uncertain effects of the engine and propeller, they fail to give any accurate account of the resistance of the water.

In the earlier history of the subject, it was supposed that models would most aptly represent ships at the same speed both for the ship and the model. The experiments at the East India Import Dock, in 1827 or 1828, seem to show a dissatisfaction with the results of small models, and some time later, M. Réech, the Director of the Ecole d'Application du Génie Maritime in France, pointed out that models of different sizes, intended for comparison, should be made to move at velocities varying as the square roots of their lineal dimensions. In this case the actual resistances would vary as the cube of the lineal dimensions. This would follow from the theory of the resistance of submerged bodies, on the supposition that the resistance varies as the square of the speed. If, again, we consider Mr. Scott Russell's theory of the length of ships—that their extreme speed should not exceed that of an oscillating wave, bearing a definite ratio of length to that of the ship, we arrive at the same conclusion, the length of the wave varying as the velocity squared.

PROPOSED EXPERIMENTS.

The experiments upon resistance which we consider most important to be made are these:

That a ship of considerable size and fine form should be carefully selected; a screw steam-ship, with a screw capable of being lifted; with a clear deck, offering no unnecessary resistance to the air; and with little or no rigging.

That her form should be carefully measured in dock (her lines taken off, as it is technically called), and sight marks carefully laid down, so as to ascertain whether she deforms in any way when afloat.

That she should be towed at various speeds, from the slowest that can be rated to the fastest that can be obtained; and that the resistance should be ascertained by a traction dynamometer, self-recording.

That the place selected for the experiments should be a deep inland water, free from ground-swell, and such that the speed of the ship can be observed from the land as well as from the vessel. The water also should be clear enough to admit of being seen through to a considerable depth. The place, if tidal at all, should be free from cross tides or irregular currents. These conditions, it is believed, may be found both in Norway and on the west coast of Scotland.

Careful observations should also be made with a view to ascertain the direction and velocity of the local currents caused by the ship's motion. What these should be will demand careful consideration, having regard both to the ship and to the place selected, and to the *personnel* of the observers.

The same remarks will apply to the precautions necessary to prevent interference by the currents thrown back by the towing vessel or vessels, and to eliminate other sources of error. It is of especial importance that the ship which is being towed should be kept clear of the wake of the towing vessel or vessels. It might be necessary for this purpose to have two tug-boats with hawsers meeting at an angle in the form of letter Y.

It is desirable that these experiments should be performed with at least two vessels considerably differing both in size and in proportions, and, for each of them, with different conditions as regards smoothness of surface.

A third class of experiments should also be made to determine the rate of retardation of a vessel which has been made to attain a certain velocity, and then (the propelling power suddenly ceasing to act upon her) is allowed to come gradually to rest through the resistance of the water.

It would be desirable that the same vessels (and as nearly as possible under similar conditions of draught and trim) should be made use of for trials of propulsion, and that in these again a dynamometer should be interposed between the engine and the propeller, and that in this case also the local currents and waves due to the joint disturbance of ship and propeller should be observed.

We consider that experiments of the kinds which we have proposed have now become necessary, not only to the theory of resistance, but also to the practical calculations of the effect of steering and propelling apparatus, and incidentally to the design of these, and to the apportionment of engine power and driving speed.

Such experiments are quite beyond the means of anybody but the Government of a naval power in time of peace, possessing ships which must be exercised with their crews and staff of officers. There would of course be extra expense attending such trials; but this expense is in no way commensurate to that of building experimental vessels, or arriving tentatively at the suitable forms and positions for propellers.

We therefore recommend that the Council of the British Association should authorize a deputation to apply to the Admiralty to provide for such a set of experiments in the course of the summer of 1870; also that the Council should appoint a committee consisting of three members of the Association, to confer with officers of the Admiralty respecting the details of the experiments, and that the Admiralty should be requested to give an opportunity to the members of that committee of taking a share in the observations, in order that they may be enabled to make an independent report upon the results.

[TO BE CONTINUED.]

THE BLACK FOREST RAILWAY.

From the "Pittsburgh Evening Chronicle."

The following is an extract from a letter of C. Ackenheil, C. E., of Pittsburgh, describing the Black Forest Railway now in course of construction in the Grand Duchy of Baden, Germany:

About 30 miles of road brings the traveller to the foot of the heavy grade, at Hornberg. This little town is one of the most industrious places in the Black Forest, celebrated for its manufacture of clocks and musical works. In nearly every house parts of watches and clocks are made. The scenery there has great resemblance to that of the "Cumberland Narrows," Maryland. An old castle, built on a conspicuous rock, gives the place a very romantic look. 180 ft. above the town is the railroad station, 1,287 ft. above sea level; the railroad summit is 3,030 ft. One of the main tributaries of the Danube has its sources here. By tunnelling the summit, this height has been reduced to 2,780 ft.; therefore the whole rise between the beginning of the road and its highest point is 1,493 ft. The air line between these two points being only 7 miles, that gives for every mile of this line 213 ft. elevation. It was a hard task for the engineers to establish a line with a suitable grade, bringing in account the adverse influence of climate. The winter in those mountains is very severe, subjecting the road to heavy snow-drifts. However, by the most careful study of the ground; by the most skilful supervision of the surveys of Robert Gerwig, Chief Engineer, one of the ablest engineers in Europe; by investigating almost every inch of the topographical features, the engineers succeeded in establishing, after several years' work, a line answering, in the highest degree, every requirement in location, grade, and all other features of a first class railroad.

It was stipulated that the grade should not exceed 2 ft. per 100, or 105 ft. per mile; no radius should be less than 1,000 ft., a 5 deg. and 45 min. curve—rules which have been strictly followed. The air line of 7 miles was lengthened into 15½ miles

by entering in side valleys; by going for instance on the north side of the main valley and returning for two miles on the south side; then making a turn again towards the north; higher and higher on the sides of the mountains the road climbs to the summit, in numberless bends. One tunnel follows another in quick succession. About half way, looking down into the valley, you are at least 600 ft. above its level; 200 ft. below you—nearly perpendicular—you see the railroad; 200 ft. further you see the road again, and at last, over 200 ft. further, you see the waves of the creek like a small silver thread between the rocks. From Hornberg to the summit there are 29 tunnels, the total length of which is 28,500 ft. The longest is the "Summit" or "Sommerau" tunnel, 5,600 ft. long; the next is the "Gremmelsbach" tunnel, 2,900 ft. long. The most remarkable was the "Triberg," so called "S" tunnel, 2,700 ft. long, having the shape of an "S," the most difficult work for construction on the whole road, because no shaft could be used. The heading of this tunnel was completed last November, after three years' work. The lengths of the other tunnels vary from 500 to 2,400 ft. One viaduct is to be constructed about 800 ft. long and 80 ft. high, all of cut stone. The geological formation is entirely granitic, which renders tunnelling a very hard and tedious work. The construction of the road was commenced in 1867, and is rapidly progressing; on the average they do from two to three feet of tunnelling on one heading in twenty-four hours.

The road will be finished 1873, and will be one of the greatest works of engineering in Europe. The cost of these 15 miles is about $5,000,000, and must be considered very high, the wages for labor being very low, from 60 cts. to $1 a day. Only nitro-glycerine, mixed with sand, is used for blasting; it has been proved the most effective material, and if worked with care it is not at all dangerous—not more than common powder. The track will be of steel rails, which are now adopted in Europe on all important railroads.

THE MARQUETTE MINING REGION.

BY MAJOR T. BROOKS.

Abstract of a paper on the Geological structure and working of the deposits of the Marquette District. (See Frontispiece.)

The best method of extracting a deposit of ore will necessarily vary with the nature of the ore, its geological structure and topographical position. No one, we think, can doubt the policy of having begun work at many of the openings of our iron mines by quarrying, which may be defined as mining in open excavations.

Having a large mass of pure ore before us, of unknown form and size, and covered by but a small amount of earth, it would certainly be folly to incur the delay and cost incident to sinking and drifting, to open ground thus already opened by nature and ready for us to win.

Our ore deposits are, as it is the design of this paper to prove strata beds, instead of veins; their extension, like coal beds, is laterally and not vertically; hence, stripping or uncovering, when it is not too heavy and expensive, is the true method of working.

When the earth or rock covering becomes heavy, and treacherous hanging walls loom threateningly over our heads, should we attempt to work the deposit as an open cut, we may as well pause, and ask whether the centuries of experience by miners in other districts and other countries, under circumstances similar, and, perhaps, sometimes more difficult than ours, may not have pointed out some more practicable, permanent, and economical method of extracting ores, than the very obvious and simple one of quarrying.

Which one, if any, of the well-tried systems of mining that have been wrought out and perfected elsewhere, can be advantageously applied to Lake Superior iron mining, is a pregnant question at this period in the history of our iron industry, and one that should soon be answered at all our mines.

In the time that is coming those mines which have been opened, and are now

being worked as quarries, will soon have to make many changes in their system of working, their traditions, organization and labor. The common laborer with his pick and shovel, horse and cart, barrow and derrick, will play a far less important part. In their place will be found the skilled miner, steam-engines, nitro-glycerine (perhaps) and the tallow dip. Mining engineers, mining captains, and timbermen will be found in the staff of the mine. Then our mines will continue in a long career of prosperity, which may be interrupted by irregular or unwise tariff legislation, but which can only be terminated by the exhaustion of the beds, which must sooner or later come. The critical period for each mine is the transition from the old to the new system; to stop quarrying and begin mining in time to make no interruption in the supply of ore. It would be a very serious drawback for any mine to be able to supply only one-half its regular customers for a season or two, especially if there happened to be active competition. This danger is plainly pointed to by the disaster last fall at the New England slate ore opening. The hanging wall of talcose schist fell in, destroying a large amount of timber work, and completely stopping mine work for a long time. A large expenditure of time and money will be required before the mine can be again made productive. This danger is increased by the fact, that reserves of ore from which to draw during times of low product, are unknown in the district. We "pick out the eyes of our mines," to use a Cornish expression, at the close of every shipping season.

Probably the most important preliminary question connected wito the adoption and putting in practice of a permanent regular system of mining, and the construction of the necessary works which are to affect the whole future of the mine, and determine to a great extent the amount of its profits, is that of the geological structure of the ore deposits themselves. Certainly, to extract a mass of hidden ore advantageously, the more we know of its position, form, size, direction and dip, and the better our acquaintance with the nature of the associated rocks, particularly of the hanging wall, the better we can plan and execute our attack on such ore mass—the better we can locate our permanent machinery and shafts, our tunnels, pockets, dumps, tracks and roads, waste and stock piles, and place the necessary houses.

I may here properly quote a portion of a letter from Warrington W. Smythe, Crown Inspector of Mines in Great Britain. I sent him a rough sketch, giving an approximate section of the Lake Superior mine similar to the one presented, and asked him to name some book which treated of a similar case. He very kindly replied in a private letter, from which I venture to make the following extract:

"* * * We have no English books which deal with the problem you have set before me; nor have we, indeed, any case analogous to that of the very remarkable orey bed which you describe. The only work which we have in Europe dealing pretty fully with the working of deposits of various thicknesses and position, is that of M. Ponson, a Belgian, on Coal Mining, published at Liege, in three octavo volumes, with a folio of plates. In this you would see how the Belgium coals get into a position alternately flat and highly inclined, and have to be worked in the two cases by different methods. But then these seams are thin, and offer smaller difficulties. Your district will have, I suspect, to follow out the plan which the French are doing very largely in some of their coal mines, where the beds are from thirty to ninety feet thick, but broken and turned up usually at high angles. This is the mode of working, as they call it, by *remblais*, or filling up as they go on, with loose stuff—clay, coal-measure, shale, grits, etc.,—taken down for the purpose, often through special shafts and drifts, so as not to interfere with those devoted to coal raising."

If the above general view of the question be correct, then it is evident that all sources of information as to the details of geological structure should be exhausted before a plan is made and underground work begun; and then, on the uncertainties which are inherent to the question, our system should be so devised as to have sufficient elasticity, so to speak, to meet probable unknown conditions which the progress of mining may develop. Fortunately, the vast excavations now open to daylight at our several mines present a fine opportunity to study the gen-

eral structure. The details are in many cases obscure, the quarrying process having removed and deposited in stock or waste piles material which showed many curious geological phenomena, and which could have been studied to advantage.

The first and by far the most important inquiry in this study of geological structure, and the one to which the remainder of this paper will principally relate, is this: Do our Marquette iron ores occur in beds or veins; that is, are they highly metamorphosed and disturbed aqueous deposits, which were laid down at the same time as the associated rocks, or have they been since formed?—in which case they must be either volcanic dykes, or else fissures or segregated veins.

This question is not presented as a purely scientific one, because as a theoretical question among geologists it has been settled. But it is presented as a practical one, bearing directly on the economic extraction of iron ores—and as a question on which those engaged in the direction, management, and working of our mines widely differ.

If our deposits or any of them are true veins, then the regular system of vein mining which is finely exemplified in the Lake Superior copper district, covers the case; except that in some instances our deposits, being of unusual thickness, may require some modifications in the system. If, on the other hand, our ores constitute strata beds, conformable with the rocks with which they are asssociated, then we have a structure entirely different, and requiring a different mode of procedure, and in this case should look for our models to the very thick coal beds of France, or perhaps better to those of Belgium, as as being more contorted, folded, and disturbed—hence, more closely resembling, in their irregularities of dip and thickness, the highly metamorphosed schists of this district. At present several of our mines are directed and managed in the full belief that the ore deposits are either true veins, or at least have such essential qualities of veins that they may safely and advantageously be wrought as such. In some instances, the mine superintendents are full believers in the bedding theory of formation. Probably in most cases there is no settled belief on the subject, nor much faith in the advantage of such knowledge; but in place of any such doubt, a feeling of certainty to the effect that geologists are dangerous dreamers, and that the Lake Superior iron mines present inexplicable phenomena, such as were never before seen in the earth, and such as geology will never explain, nor find duplicated elsewhere. Lake Superior iron ores being almost exceptionable in richness, so they would naturally be in structure.

In the hope of presenting a full logical proof on this question, to the few who are in doubt, I shall, even at the risk of being tedious, cite those definitions and characteristics of veins which are taught and accepted by the best authorities, together with the characteristic phenomena of our ore beds, thereby hoping to prove that they cannot be rated as veins or igneous deposits, but, on the contrary, are true aqueous beds, or rock layers.

(A.) A true vein is a fissure or crack in the solid crust of the earth, of indefinite length and depth, filled with some metallic ore or mineral substance, different from the containing rock. Veins, in most instances, extend across the lines of stratification of the formation in which they lie. In the rare instances in which they conform with the bedding, such coincidence is not for any considerable distance.

Now, if we look among the beds of magnetic and specular hematite ores of Lake Superior, Missouri, New York, New Jersey, and, I feel safe in adding, Sweden, we shall find them conforming exactly with the stratification of the containing rock, and in no instance crossing it, as veins almost invariably do. (It should be here remarked, that, owing to the great metamorphic and dynamic action to which the formations under consideration have been subjected, the bedding is often obscure and sometimes entirely hidden.)

(B.) Veins are usually in groups, parallel in course, or strike and dip.

Beds of iron ore, if several in number and regularly folded, present similar phenomena on the surface, as is seen at the Mt. Hope mines, and others in New Jersey. It is safe, however, to say that the Lake Superior ores never present this appearance. The fact that there is a general east and west parallelism is not to the point, for at the Jackson, Cleveland,

Lake Superior, and Washington mines there are dips in the same bed to every point of the compass, and from vertical to horizontal within a very small area.

(C.) Veins very seldom underlie at a less angle than 45 deg. with the horizon, and, as a rule, are much nearer the vertical. Their prevailing direction is downward toward the centre of the earth.

On the other hand, our iron ores are often horizontal and seldom vertical. The many folded beds which are plain to be seen at Lake Superior mines (see sketch giving a section of the Lake Superior mine), and undoubtedly exist at the other mines, must contain parts that are horizontal at the bottom and top of each alternating fold.

(D.) Veins generally run straight, both on the surface in their out-crop and downward; that is, their boundaries are more or less regular inclined planes. If the vein changes its course from a fault or throw, it will usually be found at no great distance, taking its first direction. This is as far removed as possible from the fact in the case of our iron ores, as is perfectly illustrated in the accompanying section above referred to.

This comparison might be continued to the exhaustion of all vein phenomena, with results as above. We might point out that the mineral constituents of veins —quartz, calc spar, fluor spar, heavy spar, and other minerals, not only are not characteristic of our iron ore beds, but, except the first, are wanting. Instead, we find in our iron mines, large beds of talcose and chloritic schists which are found in veins. Quartz is found universally associated with our iron ores, as it is in veins, but not having the same form. In the specular hematite mines, it is in thin beds interlaminated with corresponding thin beds of rich ore, or is in fragments forming a conglomerate. In the lower horizons or flag-ores, the quartz is so intimately mixed with the oxide of iron as to produce a homogeneous lean ore.

Again, the gossin, or decomposed vein matter which almost universally caps true veins, finds no counterpart in our veins. On the contrary, no perceptible change in richness, or in the mechanical condition of the ore, has been observed between the surface and lowest point yet reached in the district, say two hundred feet.

Experienced vein miners will not consider this comparison complete if I do not refer to the change in the character of the mineral contents of true veins, due to the passage of the lode from one kind of rock to another. Certain rocks are known to produce rich bunches in the lode, while other rocks give comparatively barren ground.

Nothing allied to this phenomenon has been observed in iron ores of the character we are discussing.

If the above be accepted as accurately describing a fissure vein, and as presenting correctly some of the characteristic geological phenomena of our deposits of iron ore, then the latter not only are not veins, but, on the contrary, are so unlike them that it would be unsafe to apply any of the principles, practices, or terms of vein mining to our case, without a careful consideration of the subject, else much confusion, uncertainty, and perhaps loss may ensue. This is a practical point of much importance, because many of our miners and experts, having got their experience in vein mining in other regions, are slow to modify their traditions and methods to suit the very different case presented here.

It would be still easier to prove that our deposits are not dykes or fissures, which are supposed to have been filled by volcanic agency. Any person in the district can satisfy himself on this point by an examination of a trap dyke pointed out by Mr. Breitung in the Washington mine. Neither can they be segregated veins, as could be proven. We are left the hypothesis with which we set out, and which completely embraces all of the facts adduced; that is, that the ores in question are simply strata beds or rock layers; having the same general form, origin, and structure as the layers of chloritic and talcose schist, the quartzites and diorites, with which the ores asssociated.

A simple view of the question is to regard oxide of iron as one of the half-dozen minerals which were chiefly used by the Great Architect in building our Huronian formation. Put our iron ore on the same footing as quartz, chlorite, talc, hornblende, feldspar, and argillite, and all difficulties of structure of the nature we have been considering vanish.

When the mineral oxide of iron alone was employed in the composition of a

layer, a bed of iron ore was the result; in the same way, when quartz alone was used, we find quartzite as the result; when these minerals were mixed, the silicious ores were the result, which are unfortunately twenty times more abundant than the pure ores. It is safe to say that the oxide of iron, although seldom pure, exists in all our rocks in greater or less quantity. Just the same may be said of the mineral quartz.

In brief, we may say that nature seems to have incidentally employed iron ore as a building material, just as she employed other, apparently, to her just as important materials. She does not seem to have changed her plans nor specifications when the iron ore course of crowning stones were laid.

Men, finding such ores infinitely more valuable than the other rocks, are led to suppose that some great convulsion, some means out of nature's ordinary course, were resorted to for its production.

Although foreign to our district, it is not improper here to notice the vein-like structure presented by most of the New Jersey magnetic iron mines. There it may be truly said that some phenomena of true veins can be found, and that many of the beds are worked successfully on a system of vein-mining. This fact does not shake the aqueous theory of origin which we are endeavoring to establish. The same folds exist there as here, only they are more regular and deeper. In this district, so far as yet made out, no fold is more than 175 or 200 feet from crown anticlinal to bottom of adjacent synclinal—deeper ones will undoubtedly be found—while to the east the azoic rock waves run much higher. In Sweden the ores have been followed down over 600 feet on a tolerably uniform underlay. Even in the New Jersey region the folds are not always so deep. A geological survey made by myself of the Mine Hill mines on the Durham estate, near the Delaware river, in Pennsylvania, which may be regarded as the extreme southwest end of the New Jersey iron region, developed a shallow synclinal basin, the axis of which pitched to the northeast. The result of this survey has since been published in Professor Cook's Report on the Geology of New Jersey.

A section of the Iron Mountain mine, Missouri, shows it to be a grand anticlinal fold; all of which proves that the same general law of structure holds for azoic ores thoughout this continent

I might here enumerate numerous localities in this district presenting phenomena which can only be explained by supposing our ores to have been deposited from water, and afterward highly metamorphosed. All are familiar with the Cleveland knob; its whole surface striped with alternating red and metallic bands, which bend and double back on themselves, then reverse into an infinity of angular curves, but continuing always uniform in thickness, and parallel with each other, pointing back to the still water in which were originally laid down the thin alternate beds of ore and quartz. Who that has observed the working of our mines has not seen a thin knife edge of slate make its appearance in the midst of good ore, which, growing larger as it is followed in the direction of the bedding, may entirely crowd out the ore, and occupy the entire space between the walls of the bed, but more generally is satisfied with less thickness, and if followed will, after passing its maximum thickness, begin to thin out, and finally disappear in an opposite knife edge?

Perhaps the best place in the whole Lake Superior region at which to convince the skeptical that our ores are stratified, and are, in geological structure, precisely like the overlying and underlying rocks, is at Smith Mountain. Here nature has condensed, so to speak, the geology of the whole district in a small area.

Commencing at what is one of the youngest rocks in the Huronian System, so far as developed here, that is the upper, or conglomerate quartzite, we pass geologically down next over the specular hematite (sometimes magnetic), then the several diorites and schists alternating with ferruginous slates and flag ores to the lower quartzite which is seen reposing non-conformably on the protogine and gneiss of the Laurentian System, as first observed by Professor R. Pumpelly. These rocks standing on edge, and laid bare by wind falls and fires, are as easily studied as the specimens of a cabinet.

Some of the conclusions, theoretical and practical, concerning the ores of the Marquette iron district, which the facts

above cited, and others well known, point toward, are these:

(1.) These ores were deposited by water, at the same time and in the same manner as the underlying and overlying rocks with which they are associated.

(2.) There are several horizons of ore, the upper, or youngest, being the purest, and the one from which the specular hematites and magnetic ores now being shipped from the district are mined.

(3.) That the ores of the different horizons at places so closely resemble each other, that the best scientific and practical judges have mistaken one for the other. That all the mining failures in the district have come from this mistake—which can only be surely avoided by a full geological understanding of the locality.

(4.) That at certain places in the different horizons, from some cause, the ores have become partially or wholly disintegrated, and so changed chemically, as to produce Limonite; that is, the "soft hematite" ore of the district.

(5.) That while the several ore formations are tolerably regular in thickness, measured from over to underlying rock, in their interval structure they present considerable variety in their mineral composition, being made up of oxide of iron, generally mixed with red quartz, (so-called jasper), which is often in such quantity as to render the "mixed" ore valueless.

In addition to red quartz, there are frequently found lens-shaped masses, sometimes of immense size, of talcose and chloritic schists, the form of which is described above. These alternate with similar lenses of the pure and mixed ores, the whole presenting a structure not unlike that of the muscles of an animal. As if to still further complicate the question, the same lens or layer will change gradually, from a first class "shipping ore" to a worthless "mixed ore."

This arrangement closely resembles what Dana calls "ebb and flow" structure.

Sometimes these lenses of ore and rock terminate so abruptly at their edges and are so long in the direction of one axis as to be best described as pod-shaped. A writer in the "Annales des Mines" some years since described some of the ore deposits of Sweden as "flattened cylinder" shaped masses. Such are common in New Jersey.

(6.) That since the original deposition of the ore, which must have been in nearly horizontal layers, the beds have been subjected to great dynamic action, which has wrinkled, and folded, and broken, and in some instances almost capsized the whole series of associated rocks.

(7.) The extent of the ore in the Marquette district, at least so far west as the Washington mine, appears to be limited to a narrow synclinal basin, in which are several shallow folds. The exhaustion of any given length of this basin is certain to be attained if work be continued. The quantity of ore in a given length should be approximately computed by proper surveys.

(8.) These peculiarities of structure produce in the beds endless changes in dip, strike, thickness, and quality of ore, as well as in the nature of the containing walls; hence, presents, or will soon present some of the most difficult questions in practical mining. In a few fathoms I have seen a bed, not only change its dip from vertical to horizontal, but following its strike, the same bed has abruptly changed from a thickness of forty feet to as many inches. If, at the same time, as might easily have been the case, the same bed had changed from pure ore to nearly pure jasper, the metamorphose would have been complete, embracing composition, form and position.

Perhaps the most perplexing thing the underground miner will have to contend with is the varying and treacherous nature of the hanging walls when composed of the schists above named, which practically will not stand unless supported throughout their whole extent.

(9.) The best general principle on which to extract our ores, is undoubtedly the one which has been generally followed in the district; that is, find the ore, follow it by uncovering and quarrying as long as it will pay, then abandon the opening and find a vein, where the same process is repeated; using as little machinery and skilled labor as possible.

But when this system has exhausted all the ores that will pay under it, which will speedily be done at each mine, then there will be left large amounts of ore

which may be extracted by proper mining so as to give a fair return to mine shareholders.

(10.) Just what methods will be best suited to our case and to the labor and skill available here, experience must decide. It is safe to say that a knowledge of what has been done elsewhere under similar difficulties, coupled with actual experience in this district, would afford the best chances of success. Whatever plan be adopted, time will be required for its consummation; hence, preparations for underground work must be made in time, or production must cease when quarrying finds its limit.

(11.) It is not likely that narrow beds can ever be followed so far or under such difficulties in this district as in the magnetic regions of New York and New Jersey, because ore on the mine-bank is worth nearly twice as much there as here.

I suppose that two-thirds of the mines now wrought at a profit there, would have to be abandoned if here, as will appear from the following approximate comparison. The worked beds in the Marquette district average not less than two and one-half times as thick as those in Passaic, Morris and Sussex counties, New Jersey, and the ores produced contain, at least, 10 per cent more metallic iron; and there they lift their ore and pump their water, at least, five, and probably ten times as high as is necessary at our mines. But a 65 per cent. ore is worth on our mine-banks from $3 to $4, while in New Jersey a 55 per cent. ore is worth $5 to $6 at the mine.

(12.) It is not too much to expect of geological science, that if it be given the benefit of careful records of deep borings made in and about our mines, in addition to what can be seen here and elsewhere, it will in return be able to furnish the mine superintendent with such plans and sections, with predictions as to position and quantity of unseen ore masses, as will greatly aid him in the uncertain and expensive work of opening his mine by means of shafts and drifts, as well as in the location and erection of the necessary pumping and hoisting machinery.

PORTABLE CONDENSING ENGINE.

From "Engineering."

Nearly twelve months ago there appeared in this journal a letter from Mr. G. A. Haig, of Pen Ithon, proposing certain modifications in the construction of agricultural steam-engines, and suggesting, amongst other things, that they should be fitted with air-surface condensers. In a note which we appended to Mr. Haig's letter, we stated that such a condenser as that gentleman proposed would, if furnished with the requisite amount of surface, be too cumbrous for its intended purpose. Subsequently, Mr. Haig wrote some further letters on the subject, and in these latter communications he gave particulars of a series of experiments which he had carried out on a model condenser to ascertain the amount of surface actually necessary. Some of these experiments were conducted in our presence, and the results obtained showed that, with clean brass surfaces and a blast of air through the condenser so strong that the temperature of the air was only raised from 56 deg. to 128 deg. during its passage through the apparatus, about 1.18 lbs. of steam could be condensed into water at boiling point per square foot of surface per hour. Mr. Haig's deduction from these experiments was, that the area of condensing surface exposed to the action of the air current would have to be about four times that of the heating surface in the boiler; and taking into consideration the large size of the fans required to furnish the necessary supply of air, the power required to drive these fans, and some other details, he ultimately concluded, with us, that such condensers were practically inapplicable to agricultural engines, and he consequently abandoned the idea of having such a condenser applied, as he originally intended, to an engine which is now being built for his own use.

It is somewhat curious that just at the time that this subject was under discussion in our columns, and some two months and a half after the appearance of Mr. Haig's first letter, Mr. Frederick J. Bramwell should have taken out a patent for a

method of applying air-surface condensers to portable engines, which appears to us to be practically identical with Mr. Haig's. Inasmuch as the recent publication of Mr. Bramwell's plans in some of our contemporaries has again brought the matter before the public, it may be as well that we should point out the practical objections which exist to the system of condenser he proposes. Let us, for instance, to take an example which we employed on a former occasion, examine the case of an engine having 160 square feet of heating surface in the boiler, and evaporating, say, 800 lbs. of water per hour. Supposing, moreover, the steam to be discharged into the condenser at a pressure of 15 lbs. above the atmosphere, there would have to be abstracted from each pound of it 978 pound-degrees or units of heat, to reduce it to water at a temperature of 212 deg., so that altogether $800 \times 978 = 782{,}400$ units of heat would have to be abstracted per hour by the air passing through the condenser.

In Mr. Haig's experiments, to which we have already referred, the air passing through the condenser had its temperature raised from 56 deg. to 128 deg., or 72 deg.; but, inasmuch as agricultural engines are much used at times of the year when the atmospheric temperature is above 56 deg., it would probably not be safe in practice to furnish to the condenser a less supply than would suffice to abstract the requisite amount of heat with an elevation of temperature of 60 deg. The specific heat of air being 0.238, we thus have $\frac{782.400}{60 \times 0.238} = 55{,}721.5$ lbs. of air per hour as the supply necessary; this being equal, at a temperature of 62 deg., to 732,213 cubic feet per hour. Of the power requisite to furnish this supply we shall speak presently. According to Mr. Haig's experiments, it appears that 800 lbs. of steam per hour admitted to the condenser, at the pressure we have mentioned, could be condensed by about 680 square feet of clean metallic surface exposed to the air current; and, although we are far from believing that this amount of surface would be found sufficient in practice after it had become coated with grease, etc., carried over by the steam, yet we will for the present suppose it to be so.

Let us suppose the condenser to be provided with tubes 4 ft. in length, and, say 1 in. in diameter.* To make up the surface above mentioned, 650 such tubes would be required, these tubes having thus a united sectional area of $\frac{650 \times .7854}{144} = 3.545$ square feet. As these tubes would, under the circumstances we are proposing, have to pass 732,213 cubic feet of air per hour, the velocity of this air would be $\frac{732.213}{3.545 \times 60 \times 60} = 57.37$ ft. per second; and to give this velocity—even supposing no frictional resistance to exist—would require a pressure equal to a head of 0.75 in. of water, or, say 3.9 lbs. per square foot. But each of the 650 tubes would have to pass $\frac{732.213}{650 \times 60} = 18.8$ cubic feet of air per minute, and the frictional resistance due to this transmission would be equal to a head of about 0.68 in. of water, or, say 3.54 lbs. per square foot, so that the total pressure necessary to force the required quantity of air through the condenser would be $3.9 + 3.54 = 7.44$ lbs. per square foot. The net work to be done by the fan, therefore, would be to deliver $\frac{782.213}{60} = 12203.55$ cubic feet of air per minute against this pressure, a performance equivalent to $12{,}203.55 \times 7.44 = 90{,}794.4$ foot-pounds of work, or over 2.7 horse-power. This, it must be remembered, is the net work performed by the fan, and the power required to drive the latter, and consequently abstracted from the available power of the engine, would certainly not be less than 4-horse power, an amount equal to from 20 to 25 per cent. of the total indicated power which an agricultural engine would probably develop under the circumstances we are supposing.

So much for the power required to supply the air to the condenser; and now for some other considerations connected with the apparatus. Mr. Bramwell speaks in his specification of making the area of the condensing surface equal to twice the boiler-heating surface, when the condenser

*In the drawings attached to his specification, Mr. Bramwell shows condensers made up of a series of flat surfaces, forming rectangular channels; but, inasmuch as we have not precise information of the proportions he proposes to use, we have preferred in our example to suppose that 1 in. tubes are employed. We may add, that in order to give the necessary compactness to a condenser with rectangular channels, it will be almost compulsory to adopt proportions giving almost exactly the same frictional resistance as the tubes adopted in our example.

is merely required to reduce the steam to water at 212 deg.; but Mr. Haig's experiments clearly showed that such a proportion of surface would be very insufficient, and the allowance of 680 square feet of surface which we have supposed to be provided to condense 800 lbs. of steam per hour, is itself low. Even, however, if the tubes of such a condenser were made of thin brass, weighing but 1 lb. per square foot, they would weigh over 6 cwt.; and the weight of the whole apparatus, including casing, connecting pipes, fan, etc., would probably not be less than 13 cwt. or 14 cwt. Such a weight would be a most objectionable addition to a portable engine, and the apparatus, if employed at all, could probably be most advantageously arranged in a kind of tender hauled separately, a plan which, indeed, Mr. Bramwell suggests might in some cases be adopted. The use of the separate tender would, however, still further increase the cost of the apparatus, and we certainly can imagine but exceedingly few cases where this cost would be even approximately compensated for by the advantages which the condenser would give.

Before concluding this notice, it is desirable that we should make a few remarks on one point connected with Mr. Bramwell's plans, to which we have not yet directed attention. Mr. Bramwell, we should state, proposes to lead a portion of the air issuing from the condenser into the fire-box to support combustion, in some cases using this air to inject powdered fuel; and he says: "By taking care not to give the air which acts on the condenser too high a velocity, it will be found that the saving in fuel arising from using heated air for the combustion will largely compensate for the power required to set the air in motion." Now, in this we certainly cannot agree with Mr. Bramwell. The experiments to which we have already referred have shown that it is only by having a strong current of air through the condenser, and thus heating that air but 60 deg. or so, that the condensing surface required can be kept within anything like moderate bounds; and it thus happens that but a small proportion of the air passed through the condenser would be required for supporting combustion in the fire-box. In the example we have been considering, the evaporation of the 800 lbs. of water per hour would not probably require the consumption of more than 1 cwt. of coal in that time, and even if we allow 300 cubic feet of air per pound of coal burnt, we shall thus have but $114 \times 300 = 34{,}200$ cubic feet of air per hour required for supporting combustion, an amount equal to less than 5 per cent. of that traversing the condenser. The 34,200 cubic feet of air supplied per hour to the fire-box would weigh about 2,600 lbs., and supposing its temperature to be 60 deg. above that of the external air, it would thus carry into the fire-box an amount of heat equal to $2{,}600 \times 60 \times 0.238 = 37{,}128$ pound-degrees per hour, or 618.8 pound-degrees per minute. Even, however, if the whole of this heat were transmitted to the water in the boiler, it would suffice for the conversion of less than $\frac{2}{3}$ lb. of water per minute into steam, even with the feed supplied from the condenser at a temperature of 212 deg., so that its effect in compensating for the power shown to be required to drive the fan, would be practically *nil*.

Velocity of the Wind.—Professor Huntington, who has taken up his residence on Mount Moosilauk, in New Hampshire, U. S., for scientific purposes, says the storm on the 2d inst. was very severe. The wind gauge was used, and it was ascertained that the wind was blowing at the rate of 95 miles per hour. In the afternoon the wind increased, and he went out with the "gauge" again. The rain was pouring, but he managed to hold the gauge for 5 minutes, and then, after four attempts, each time being thrown down by the wind, he succeeded in getting back into the house. This time they found that the velocity of the wind was 101 miles per hour, and Professor Huntington thought if the gauge had been properly held it would have shown that the velocity was 120 miles per hour. The walls of the house are of stone, but such was the force of the wind on the roof that every part of the inside trembled like a leaf, and so loud was the roar, that one had to shout to make the other hear, although not more than 6 ft. distant. The rain fell in torrents.—*Engineering.*

It is stated that the intense cold in St. Petersburg, in the winter of 1867, caused solid blocks of tin to crumble and fall to pieces.

THE ACTION OF HOUSE SEWAGE ON LEAD PIPES.*

From "The Building News."

Mr Edward C. C. Stanford, F. C. S., referred to the panic which had recently been shown by the voluminous correspondence in the local papers regarding the alleged impurity of the water used for domestic purposes, and stated that it had revived the old question of the action of the purer kinds of potable water on the lead of the pipes and cisterns. The panic, known locally under the name of "death in the cistern," had been completely allayed by the remarkable unanimity of the reports prepared by Dr. Anderson, Professor of Chemistry, and Dr. Wallace, Analytical Chemist, and backed by an eminent medical authority like Dr. W. T. Gairdner. Notwithstanding, however, that the amount of lead was small, a sufficient quantity had been found in almost all the analyses of the cistern water to show the desirability of avoiding all suspicion of lead contamination, by adopting a constant high-pressure service in iron pipes, and, where they are required, of using cisterns of iron or slate. The author remarked that much attention had, from time to time, been directed to the action of the purer kinds of potable water upon lead; but it was somewhat remarkable that an equally important and much wider-spread evil of a similar character had escaped notice. He referred to the serious deterioration which lead pipes undergo which are connected with water-closets; and he brought this subject under the notice of the section in order that some light might be thrown upon the cause of the said deterioration. Dr. Fergus, a Glasgow medical gentleman, had the credit of first directing attention to the subject by tracing a close connection between the deterioration of the soil-pipes and the existence of various forms of low febrile disease in the houses into which, from the degenerated condition of the pipes, sewer gases make their escape. By means of sketches and used-up specimens of soil-pipes the author showed the nature of the action to which the pipes are subject from long use—the length of time varying from 10 to 16 years. Near the bend of the pipe leading from the closet the upper part becomes coated with a grayish white deposit that can be easily scraped off, and the interior of the pipe becomes pitted; while, exteriorly, the pipe is at first blistered at the parts corresponding to the internal "pits," and in course of time it becomes quite riddled with holes, and quite gnawed away as it were. Mr. Sanford had analyzed samples of the deposit from several soil-pipes, and had found from 86 to about 93 per cent. of the deposit to consist of plumbic carbonate, the other ingredients being calcic carbonate, silica, insoluble plumbic oxide, water, and organic matter. After noticing the chemical compounds which, in solution in water, act readily upon lead, the author said that the deterioration referred to was not due to those substances, inasmuch as they were found in the excreta, whereas the injury to the pipes took place in the air-space of the bend, and not in the water-space in which the "trapping" was effected. It has been remarked by plumbers that a piece of lime, or newly mixed mortar, in contact with a pipe, rapidly eats through it, probably by the lime combining with the carbonic acid of the outside film, and so cleaning the lead that the action of the air repeats the process. In the opinion of the author, alkalies would probably have the same effect as lime, and so clean the lead that a moist atmosphere would act on it. The effect of pure water on lead is first to dissolve it as oxide, and then this is precipitated as oxycarbonate, which is very insoluble, pure water only dissolving 1-60th of a grain per gallon. Water free from air does not act on lead; and the author therefore thought the action referred to might be due to the air carried down by the rush of water while the closet was acting, and by the carbonic acid, or by the ammonia of the gases of decomposition acting as a cleaner, the interior of the pipe being always in a moist condition. Mr. Stanford concluded by recommending the discontinuance of lead soil-pipes, and the substitution of earthenware siphons and flanged cast-iron pipes.

Dr. Fergus, in opening the discussion, recommended that soil-pipes should be ventilated, or that they should be used as the rain-water pipes. He gave some in-

* Paper read before the Glasgow Philosophical Society, by Mr. E. C. C. Stanford, F. C. S.

stances, in his professional experience, of the connection between such diseases as gastric fever, diphtheria, etc., and bad soil-pipes; and he strongly urged the periodical investigation of such pipes.

Mr. Sutherland suggested that the action might be due to sulphuretted hydrogen or acetic acid; but Mr. Stanford said that plumbic sulphide had never been found in his analyses.

Mr. Anderson believed that nitric acid, resulting from the oxidation of ammonia, might have some influence in producing the injurious effects on the pipes. This view was supported by Mr. Hutton and Mr. Tatlock.

ON THE DISTRIBUTION OF RAIN.

From "The Canadian Naturalist."

The geographical distribution of rain over the surface of the globe may be said to be proportioned to temperature, its humidity to the tides or fluctuation in the atmosphere, as indicated by the barometric variations, to changes of temperature, and to the configuration of the earth's surface.

The conditions necessary to the formation of rain are the presence of clouds (although some observers have recorded rain falling from a cloudless sky), to that of the cirrus (or snow cloud) at a high elevation, and at a low temperature (some 40 deg. below zero), together with the cumulus (or vapor-cloud). These, commingling by moist air-currents being forced into the higher region of the atmosphere by colder, less humid, and consequently heavier currents from beneath, form together the nimbus (or rain-cloud). These induce a change in temperature and electrical action, conditions necessary to produce rain. This is carried by clouds and currents of wind and distributed over the lands of our continents, thus watering the earth, supplying vegetation, and the various wants of mankind, and returning again by the rivers to the sea. From the surface of the ocean pure aqueous vapors are constantly ascending to supply the unceasing requirements of the organic and inorganic world.

Rain clouds are attracted to certain localities more than to others, for it was shown that at Ulleswater (England) the great heat of 1866 caused a great increase in the amount of rain, owing to its condensation by the mountains in that district. But beyond the formation of the surface of our globe, there are other conditions which supply natural conductors, such as the pointed extremities of the leaves of trees and of plants. May not our primeval forests have given rise to a different meteorological condition of a former world? The great coal formations may be taken as an example in illustration of this.

Many countries have been made sterile by cutting down indiscriminately the whole of the trees. Such, indeed, is actually the case in the recent deserts of Syria, Chaldea, and Barbary. The "oases" of the desert are nothing more than a few trees purposely left as a shade for the weary traveller.

The value of several estates in the West Indies has been greatly diminished by the cutting down of the trees upon them, and the rain-fall over large regions of our continent is much diminishing, owing, no doubt, to the large and extensive clearances of our forest; while, on the other hand, the rain-fall in the upper province of Egypt has been increased tenfold by the planting of twenty millions of trees by Mehemet Ali.

Until two years ago rain in that province was unknown; but in twelve months ending April last, there were actually fourteen days on which rain fell, and later there fell a heavy shower—a phenomenon which the oldest Arab had never witnessed. Here we see rain returning to the desert on restoring trees.

In Spanish America, lakes have had their area diminished and their shores dried from the general removal of the trees by the Spaniards; but now that cultivation has been resumed by the enterprising Americans, these lakes are being again filled up with water, and the shores are once more plentifully supplied with rain.

Extensive drainage, although beneficial to the rapid growth of plants and to the profit of the agriculturist, may also tend

to diminish the rain-fall by robbing the springs of their supply, and by conducting the surface water more rapidly to the rivers and to the ocean.

Those lands near the sea over which the wind transports the aqueous vapor there acquired, are, as a general rule, the most plentifully watered, while those distant from this source receive less in amount; these facts are fully borne out by actual observations. And may not the diminished rain-fall in England be attributed in a great measure to the extensive surface drainage by drain-tiles and other methods, which are resorted to to promote the rapid growth and excessive yield of grain and some of the other agricultural products?

It will be seen that rain increases with the temperature, from the fact that hot air holds more water suspended than cold. The humidity of the atmosphere attains its maximum at the sea shore, and there tends to produce the greatest amount of precipitation. These causes are always present, but in a modified degree, and frequent, though small, showers are the necessary consequence; heavy and violent rain storms are of rare occurrence there.

In proportion as the mercurial column in the barometer falls, there is more chance of rain being formed, inversely in countries with a high barometric pressure, such as on the 30th deg. of latitude, where there is very little rain. Such regions have a tendency to become deserts.

Variations of temperature and irregularities of climate increase the showers of rain; and the formation of the soil plays also an important part in the production of rain, for ascending concave surfaces of soil receive a maximum, more especially when exposed to rainy winds, and more rain falls in *wooded* than in *bare* districts.

It rarely or never rains on the coast of Peru, in the great valley of the River Columbia, in that of the Colorado in North America, the Sahara in Africa, and the desert of Gobi in Asia, while in Patagonia and Chiloe it rains almost every day.

Days of rain are more numerous in high than in low latitudes.

In the region of Calmus it rains during a part of every day, the fall amounting to 225 in. in the year.

The heaviest fall of rain on our globe takes place on the Khasia Hills, to the north-west of Calcutta, and amounts to 600 in. annually.

The greatest amount which has fallen in the vicinity of Montreal in one hour was 1.110 in.

These observations extend over a period of upwards of twenty years.

Below is a table showing the annual mean amount of rain-fall at some of the principal stations on our globe. The amount is in inches and hundredths:

	In.
Madras	55.10
Bombay	75.00
Canton	78.00
Sierra Leone	87.00
Rio Janeiro	89.00
Barbadoes	72.00
Vera Cruz	183.00
Bergen	89.00
Stockholm	19.67
Copenhagen	18·55
Brussels	29.96
Naples	29.94
Rome	30·86
Paris	22.64
St. Petersburg	17.65
London	22.00
Oxford	27.10
Cork	40·00
Dublin	24.00
Glasgow	21·33
Aberdeen	28.87
Manchester	36.00
Liverpool	34.00
New York	43.50
Cambridge	44.48
Albany	40.67
Baltimore	40.98
New Orleans	52.31
Cincinnati	48.63
San Francisco	22.00
Washington	41.20
Halifax	43.44
St. John, N. B.	42.10
Toronto	31.50
Montreal	36.00
Quebec	39.10

It is stated that Dr. McQuillen has exhibited, in the Microscopical Department of the Academy of Natural Sciences at Philadelphia, slides of blood corpuscles of men and the lower animals, to which chloroform and nitrous oxide had been administered, to show that there was no morphological change in these bodies after administration of anæsthetics, as stated by certain physiologists in England. He showed specimens also in which, the blood corpuscles having been brought into actual contact with chloroform and ether, disintegration had taken place.

THE GUNS OF THE HERCULES.

From "Engineering."

We are told that the guns of H.M.S. Hercules have been disabled, that now our finest fighting ship is of no use except as a ram, that probably she will have to return to England forthwith to refit, and that all this dreadful mischief has been occasioned by the breaking up of the Palliser shots during practice before they passed the muzzle of the gun, with the result of seriously scoring the tubes. Says the "Times:"

"Whether the damage is of a sufficiently serious nature to cause the ship's immediate return to England or not, the fact remains that the guns of our heaviest broadside armored iron-clads have been for a time disabled by their own shot, and that every time any gun fires these projectiles there is attached the probability of similar disadvantageous results to the gun being attained. The accident to the Hercules's guns brings us no new knowledge on the subject. Every one was aware from the first hour of the introduction of the Palliser chilled shot into the service, of their brittle character, but it required that their destructive character when breaking up in the tube of a gun should be exhibited upon such costly weapons as the 18-ton guns of the Hercules, and at a distance from a home port, before the danger of such a mishap occurring in a probable time of war could be properly appreciated."

From this text the "Times's" leading article is written, and it points out the grave necessity of proving definitely how far the Palliser shot really are reliable, and then, leaving the direct question, it turns to the consideration of the relative penetrative power of the Palliser and Whitworth projectiles, when fired against oblique surfaces. This is a highly important question, but it is one entirely apart from the breaking up of shot in a gun, although the "Times" apparently does not think so, if an opinion may be formed from the amount of space it gives to the reprint of a discussion which followed Sir Joseph Whitworth's paper on the penetration of armor plates, read before Section G of the British Association at Exeter last year.

The whole story of the disablement of the Hercules, as recorded, is, however, marvellously distorted. The facts were these: only one of the Hercules's 10 in. guns has been damaged seriously, and that was occasioned by the bursting of a chilled iron shell, loaded with a 10 lb. charge, in the bore of the gun, an accident which split the steel tube for a distance of two or three feet.

Thus, instead of the whole armament being disabled by the breaking up of the shot, and consequent scoring of the steel barrels, we have the "A" tube of *one* gun split by the premature explosion of a shell —a very different matter.

Putting aside the magnificent exaggeration of the "Times," and regarding the casualty as it really occurred, it is serious enough, and the cause has yet to be explained. It was a chilled shell that caused the damage, and we have Major Palliser's assurance that they were not of his design, but of a pattern avowedly so bad that the few which had been made were intended for remelting. But it by no means follows that, defective as the shell was in pattern, it ruptured from brittleness of material. It is no very uncommon thing for shells to burst in the barrel of a gun, as, for instance, some two years ago, when the muzzle of a 7 in. gun was blown off by the premature explosion of a common shell. But it is not necessarily the failure of the metal which brings about the catastrophe; it is more probably some slight retardation or unevenness in the flight of a projectile as it leaves the gun, which is sufficient to discharge the fuse; or the latter may be accidentally too sensitive; and if such a cause induces a premature explosion, the consequences will be equally disastrous, whatever the material of the projectile.

It is too soon, however, to speculate upon the precise causes which caused this accident to the Hercules's gun; in a few days, however, the official particulars will have been made public, and then we shall be enabled to form an opinion. Meanwhile it is satisfactory to know that the alarming reports published have so slight a foundation.

That the steel tube of the 18-ton gun cracked so extensively from the effects of

the explosion is, however, an important fact, and points out the weakness of our service guns, not only of the heavier calibres, but of the smaller bores. The barrels are all made of Firth's steel, carefully tempered in the solid, and afterward bored, and, though every care is devoted to their construction, several casualties similar to that on board the Hercules have occurred. It is certain that coiled iron tubes show a greater power of resistance, owing to the different arrangement of the material. It is only recently that one of Palliser's converted guns, lined with a coiled tube, successfully resisted the explosion of five common shells, purposely burst in the gun, and each loaded with a heavier charge than that which disabled the Hercules's 400-pounder, the only damage wrought being a bulging of the tube. But whether this special advantage possessed by the coiled tubes counterbalances the superiority of the steel barrels in many other respects, has yet to be decisively proved.

The time may be soon coming when a new chapter in the history of our heavy ordnance will be commenced, and the Whitworth system may at last supersede that which, originally Sir William Armstrong's, has developed into the Woolwich service gun. But it remains to be proved how great a practical superiority exists in the former plan—a long, slow, and costly process. With regard to the relative capabilities of our ordinary projectiles, as compared with the Whitworth flat-headed shot, for penetrating inclined surfaces, the challenge of Major Palliser is well calculated to settle the long disputed question. But when the practical superiority of the Whitworth system of guns and projectiles over those of the service has been ascertained beyond a doubt, the time will have come to abandon the latter, and start afresh with the former, and its advocates may rest assured that such a change will not be precipitated by unreasonable and exaggerated statements of the deficiency of our existing armaments.

THE CENTRAL IMPERIAL SCHOOL AT PARIS.

From "The Builder."

The Central Imperial School of Arts and Manufactures is a highly esteemed and most important educational establishment. By its means many pupils who cannot avail themselves of the opportunities offered by the great Polytechnic School, are enabled to obtain a most complete and practical education.

For the purpose of comparison, we will give a short sketch of the Polytechnic School. It was founded in the year 3 of the Convention (1794), for the instruction of young men in mathematics and drawing for the artillery and engineer corps. None but candidates who can pass a very severe examination in mathematics are admitted. Its effort has always been to educate, above all things, good engineers; and some of the most celebrated military and civil engineers have been bred within its walls. Still, the time required by this school (7 years), including the preparatory and complementary studies, is much too long for candidates who are anxious to commence their practical and money-earning career as soon as possible. The difficult preliminary examination also excludes a great number of candidates. Again, more than half the pupils of the Polytechnic School choose the military service, whilst the greater portion of the other half abandon the civil services to follow scientific pursuits. This is why the admirable Polytechnic School has never been able to satisfy the ever-increasing demands of industry.

The Central School, therefore, fills up a manifest deficiency in the French system of technical instruction. It was founded in 1829 by the celebrated chemist Dumas, assisted by three other gentlemen, without any aid from the Government; but, after some years of success, it first of all passed into the hands of a proprietor, and was then transferred to the State. In the Central School have been educated a considerable number of able engineers, who have taken high rank as constructors of railways, etc. Many directors, managers, and other functionaries of important industrial establishments, civil engineers, mechanical engineers, architects, etc., have emanated from this school.

The Central School is very popular,

even with persons of narrow means, though what in France is held to be a high charge (800 francs, £32 a year) is demanded from pupils. The Government and several of the departments have founded scholarships in favor of the sons of parents in very humble circumstances, and in some cases money for board and lodging has been added. The sons of rich parents pay for their education, as they naturally ought; whilst the doors of the school are also open for the sons of artisans, who have given proof of the talents necessary to profit by the instruction.

At the Central School the pupils are compelled, whatever may be the careers they intend to follow, to attend all the courses, and to pass very strict and frequent examinations. During the first year the instruction is purely theoretical. In the second and third years theory and practice are blended. The teaching is not confined to unaided oral instruction; for laboratory experiments, and mineralogical and geological excursions, are made use of to complete what the lectures of the professors have commenced. As we have stated, there are frequent compulsory examinations during the courses and at their close, in addition to which there are searching examinations at the termination of each year's studies. The effect of this system is to keep the pupils always up to their work. Discipline is also strictly maintained.

The Central School is quite international and cosmopolitan in its character; pupils of all nations are admitted on the same footing as natives of France. Not a country in Europe is without a representative, and at one time or another pupils have come here from every part of the civilized globe.

There can be no better way of showing what this institution imparts to its scholars than the quoting in full the programme of the three years' studies.

First Year.—Analysis and general mechanics, 60 lessons; general physics, 60 lessons; inorganic and organic chemistry, 60 lessons; theoretical and applied kinematics, 24 lessons; construction of machines, 20 lessons; hygienics and applied natural history, 20 lessons; mineralogy and geology, 30 lessons; architecture, 10 lessons; industrial drawing, 20 lessons.

Second Year.—Applied mechanics, 60 lessons; strength of materials employed in machines and constructions, 24 lessons; construction and mounting of machines, 60 lessons; analytical and industrial chemistry, 40 lessons; metallurgy, 20 lessons; civil constructions, 60 lessons; industrial physics, 45 lessons; industrial and commercial legislation,—ceramics, 8 lessons; dyeing, 12 lessons; glass-making and mining, 20 lessons.

Third Year.—Applied mechanics, 60 lessons; construction and erection of machines, 55 lessons; analytical chemistry, 20 lessons; industrial and agricultural chemistry, general metallurgy, and metallurgy of iron, 60 lessons; mining, 20 lessons; public works, 60 lessons; steam-engines, 35 lessons; railways, 40 lessons; naval constructions, 25 lessons.

In addition to the above the following practical exercises and studies are required:—

First Year.—Various chemical manipulations; exercises in general physics, stereotomy, and taking of plans; architectural and topographical designs, and working drawings; problems in the infinitesimal calculus, general mechanics, and general physics. During the vacation, after the first year's studies, the pupils are expected to make plans of buildings and machines; also to write an essay on the resistance of materials.

Second Year.—A practical essay on the flow of gases, with the aid of an anemometer and a ventilator; each pupil to draw up a paper on the subject. Construction with bricks according to given plans of various kinds of chimneys, a baker's oven, a lime-kiln, a hot-air stove, etc. Each pupil to make a survey and draw a plan of a watercourse, and measure the volume of water in a stream; a paper to be sent in on the details of these operations. Practical exercises in a factory on the construction of machines. Twenty-seven manipulations in analyzing and assaying. Drawings and projects of machines and buildings. During the vacation after the second year, the pupils to visit manufactories, etc., and to hand to the director, on resuming their studies, a diary, giving a summary account of the studies made and the factories visited; an album containing notes and sketches made on the spot; fair copies of the most remarkable objects contained in the album, and a paper on questions in applied mechanics.

Third Year.—Projects in two series: the

first on the more important subjects in all the courses; the second on subjects connected with machines, buildings, metallurgy, and chemistry.

A NEW WATER-COLUMN MACHINE.

Translated from Der Praktische Maschinen Constructeur.

Among the machines for raising water by the work of water, the simplest and most effective are those in which power is derived from a great head, and raises a volume of water to a height less than the head. In this way a small constant supply of water, with sufficient head, will raise a large quantity. Again, a large volume of water may be made to raise a smaller quantity to a higher level.

FIG. 1.

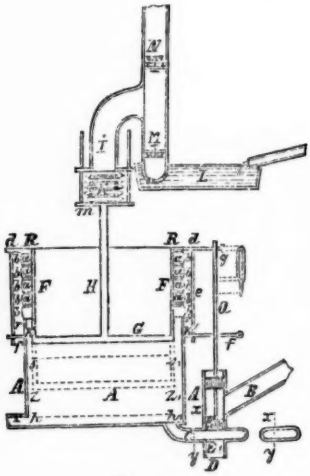
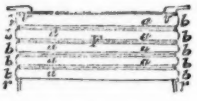


FIG. 2.



Very little use has been made of those machines by which water is raised to a higher level by means of columns from 3 to 10 metres in height, giving a quantity small in proportion to the diminution of the head. The reason that other water machines, more complex, are employed when these would answer, may lie in the difficulty of fitting the piston, which must be of so large dimensions as not to cause a great loss of work from resistance.

The figures represent machines in which an attempt is made to diminish resistance as much as possible, to make motion smooth and elastic, and to dispense with such contrivances as are required in the ordinary machines to complete the motion of the guide piston after the water in the cylinder is cut off; a necessity caused by the non-elasticity of water.

The first of these objects is accomplished by the peculiar construction of the piston and the cylinder; the second by the use of water and air together.

The single-cylinder machine (Fig. 1), consists of the following parts: A cylinder, A, of wood or iron, which communicates at D with the air, and is connected with the tube, B, which leads to the reservoir of supply. In the common machine this connection is regulated by the piston, E, so that when the communication is made with the air, that with the tube, B, is closed, and conversely. Above the cylinder is the air-tight cylindric part, F (Fig. 2), which consists of steel rings, *a a*, joined by a soft elastic rubber membrane, *b*; for this may be substituted soft leather. The connection with the piston at *r*, is made air-tight. The driving piston moves the piston, *m*, by means of the rod, H; this piston, with K, closing the tube, I, which is air-tight below. The part K, constructed like F, imparts motion to the piston, *m*, which, by its downward stroke, draws water from the reservoir, L (supplied from the same source as the tube, B, or from any other); and by its upward stroke drives it into the tube, N, raising it higher at each stroke.

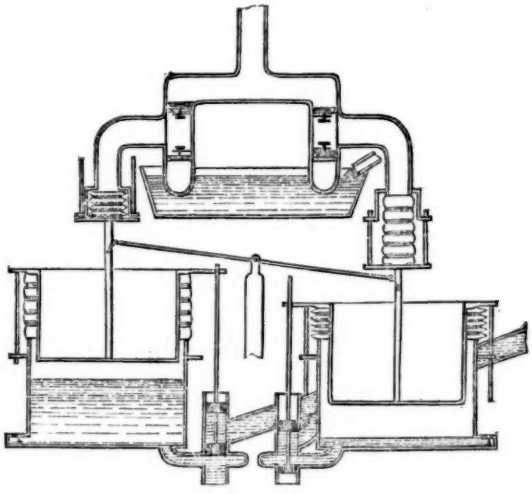
Upon four sides of the collar, R, R, are rods, *d* and *e*, which move in well-oiled guides, and by this means steady the motion of the piston (G). The part K can be removed from the lower part of the tube, I, and for it an ordinary piston may be substituted.

The piston, E, is moved by a rod, Q, which has on its upper part a long slot on

which the part g moves. To prevent pressure from one side on the piston, E, a counter-piston is set at the proper height.

The action of the machine is as follows: At first, the tube, B (Fig. 1), is empty; F is compressed by the weight of the piston, G, which descends to ZZ″; K is expanded, and the guide-piston takes the position E. To start the machine, water is admitted at B, and passes through C to the cylinder, A. Until the water reaches the level, hh, there is no increased pressure on the piston, G, the pressure of the atmosphere which can escape through the floating valve, remaining constant. When the water has passed the level, hh, the valve, h, closes, so that as the level of water rises, the air in the cylinder becomes condensed and by its pressure raises the piston, G. At the same time, K is compressed and works as long as the piston remains at E; that is, until the arm, g, reaches the upper end of its rod and raises it to the position, E. The water now ceases to rise in the cylinder, and the piston, G, is raised a little by the expansion of the condensed air. The point E should be reached before the water has reached KK, so that the portion F may not be wet. In the figure, ss is the highest level of the water in the cylinder. The air is now admitted through D into the cylinder, A, and the water escapes through D.

FIG. 3.



This causes the air above the surface of the water to expand, and the piston is forced down by the atmospheric pressure and its own weight until the arm, g, again connects with the rod, and the piston takes the position E, which is made to happen at the time when the water has, by a suitable adjustment, descended to hh.

The construction should be so arranged with reference to the height of the water-power and the required work, that after the rising of the water level above hh, only so much air remains in the cylinder as is necessary to complete the motion of the guide-piston; since a greater quantity would cause a loss of work.

The size of the working parts, G and m, must be regulated according to the head of water-power and the height to which water is to be forced. For example, if the head of supply is 4 metres above the line, KK, and water is to be raised to a height of 20 metres, the working surface of m (resistances not taken into account) should be $\frac{1}{5}$ of the working surface of G, and a quantity of water equal to $\frac{1}{5}$ of that discharged at D will be raised to the required height (loss of work not considered).

In comparison with the work of ordinary machines (in which a contrivance like F could not be used with advantage on account of the great pressure), this

machine works with greater expense of power; but its quiet and continuous motion without shock, and its simpler construction, compensate for this defect.

AIR IN COAL GAS.

From "Engineering."

Although it has long been a recognized fact that the illuminating power of coal gas is diminished by an admixture of atmospheric air, yet but comparatively few experiments have been made to determine the amount of this deterioration under various circumstances. In 1860, however, Mr. Carl Shultz made some investigations connected with the subject, and before speaking of some more recent researches, it may be interesting to state the results he arrived at. One principal deduction made by Mr. Shultz from his experiments was, that the illuminating power of ordinary coal gas is diminished to the extent of half of one candle for each one per cent. of air present; but in the case of very rich bog-head cannel gas he found a remarkable exception to this law. This gas, he found, when burned in an Argand burner, might have as much as 12 per cent. of air added to it without diminishing the illuminating power of the flame; but, curiously enough, if an intensity burner was substituted for the Argand, this gas was found to conform to the law which we have already mentioned as applying to ordinary gas. This result, we are inclined to think, must have been due to the fact of the gas when burnt pure in the Argand burner not receiving a sufficient supply of oxygen, and that, on the other hand, when the mixture of gas and air was burnt, this deficiency of oxygen was made up by that of the air mixed with the gas. In 1862, also, an important *memoire* by MM. Audouin and Bérard "on the various burners employed in gas lighting, and researches on the best conditions for the combustion of gas," was published under the auspices of the French Government, and this *memoire* contains particulars of some other experiments on the effects of mixing air with coal gas. MM. Audouin and Bérard employed in their experiments two gas-holders, one charged with a standard gas, while the other contained gas of the same quality, but mixed with a certain percentage of air, the effect of which it was desired to ascertain. The illuminating power of the standard gas is not stated, but it probably did not exceed 12 candles. Each gas-holder supplied a bat's-wing burner, regulated to burn 140 litres (4.76 cubic ft.) of gas per hour, and the illuminating powers of the two flames were compared, that of the pure gas being taken as the unit. These experiments showed that the loss of illuminating power due to various percentages of air was as follows :

Percentage of air mixed with gas.	Percentage of loss of illuminating power.	Percentage of air mixed with gas.	Percentage of loss of illuminating power.
1	6	9	64
2	11	10	67
3	18	15	80
4	26	20	93
5	33	30	98
6	44	40	99
7	53	45	100
8	58		

It will be seen from the above table that for small additions of air, say up to 3 or 4 per cent., each percentage of air added reduced the illuminating power of the mixture about 6 per cent., while as the quantity of air was increased its comparative effect also increased until 6 per cent. of air was present. After this the comparative effect of each successive addition of air diminished, as shown in the table, the last 5 per cent. of air only diminishing the illuminating power 1 per cent.

We now come to some valuable researches on the effect of mixing gas with atmospheric air, which have been lately carried out by Mr. B. Silliman and Mr. Henry Wurtz, of New York, who have contributed a paper on the results of their experiments to the "American Journal of Science and Art." Messrs. Silliman and Wurtz's experiments were conducted at the experimental laboratory of the Manhattan Gas Light Company of New York, and they appear to have been carried out

with the greatest care. The apparatus employed consisted of a pair of gas-holders, each having a capacity of 10 cubic feet, these holders being fitted with connections, so that either could be used independently, or that the contents of one could be transferred to the other, and *vice versâ*, for the purpose of obtaining a thorough mixture of the gas and air. The air was admitted to the gas-holder by opening a cock and adding weight to the counterpoise, the amount thus admitted being roughly measured by means of a scale attached to the drum of each holder. The rough measurement thus obtained was subsequently checked by an eudiometrical analysis of each mixture, as it was found that this was the only way in which the relative proportions of gas and air present could be accurately ascertained. A prior analysis of the ordinary street gas used on each occasion was also made, and these analyses showed that the average amount of air present in this gas was rather over 1.6 per cent. The illuminating power of each mixture was ascertained by the Bunsen photometer, 15 successive observations of one minute each being made in each case, and the average being taken. The gas was burned in a 15-hole standard Argand burner, consuming 5 cubic feet per hour.

Messrs. Silliman and Wurtz's deductions from their experiments are: 1st. For any quantity of air, less than 5 per cent., mixed with gas, the loss in candle power due to the addition of each 1 per cent., is a little over $\frac{6}{10}$ths of a candle (0.611 exactly; above that quantity the ratio of loss falls to half a candle power for each additional 1 per cent., up to about 12 per cent. of air; above which, up to 25 per cent., the loss in illuminating power is nearly $\frac{4}{10}$ths of a candle for each 1 per cent. of air added to the gas; and 2d. With less than one-fourth of atmospheric air, not quite 15 per cent. of the illuminating power remains; and with between 30 and 40 per cent. of air it totally disappears. These results, it will be noticed, differ to some slight extent from those obtained by MM. Audouin and Bérard, and already referred to by us. The differences, however, are not more than may be readily accounted for by the difference in the class of burners used in the two sets of experiments, and by the fact that the gas experimented upon by Messrs. Silliman and Wurtz had an average illuminating power of about 15 candles, this power being probably considerably greater than that of the gas used by MM. Audouin and Bérard.

The experiments we have quoted strongly point to the necessity which exists for carefully preventing the admixture of atmospheric air with coal gas, and they go far to explain the fact that in small gas-works—where the facilities for such admixture are proportionately greater than in larger establishments—gas of inferior illuminating power is frequently produced. The manner in which the small percentages of air act in producing such an important reduction in the illuminating power of gas cannot as yet be said to be accurately determined; but Messrs. Silliman and Wurtz incline to the belief that the effect is not merely due to the interior combustion which takes place in consequence of the presence of oxygen, but that it is to some extent occasioned by the diluting power of the associate nitrogen, this gas absorbing a portion of the heat produced, and thus reducing the flame temperature. With a view of obtaining further information on this subject, and of throwing more light on the discovery made by Mr. Schultz, that rich cannel gas has its illuminating power increased by the addition of a certain percentage of air, Messrs. Silliman and Wurtz propose, at their earliest convenience, to make further experiments on the addition of oxygen to gas of high illuminating power, and also on the effect of making additions of carbonic acid.

Spectroscopic Observations.—Father Secchi has communicated a note to the French Academy relative to recent spectroscopic observations on Uranus. He found absorption bands different to those met with in the solar atmosphere. He also recorded some results of his investigation of Neptune. Its light gives three principal bands in the spectrum; one is situated between the geen and yellow, and another is in the blue. The spectrum accords with the green color of the planet. He reports that at Rome, during the early part of the night of the 13th—14th the sky was clouded; from 2.35 to 3.4 A.M. the sky got clear, and he registered 186 meteors, which seemed to radiate from some point in Leo

THE ECONOMICAL PURIFICATION OF ZINC CONTAINING IRON.

BY W. H. CHANDLER.

From "The Chemical News."

In the galvanizing of iron, the article to be galvanized, after being thoroughly cleansed, is dipped into a kettle of molten zinc, which forms an alloy with the iron at the surface of contact, and by repeating the dipping, the thickness of the superimposed zinc may be increased at pleasure. In the prosecution of this manufacture, the zinc is held in large iron troughs or kettles, which are rapidly corroded in those portions nearest the fire. An alloy of zinc and iron is formed, to which also the articles being galvanized, in some degree contribute. This alloy being heavier than the purer zinc, sinks to the bottom, and, from time to time, is removed by perforated ladles.

The composition of the alloy is of course somewhat variable, depending upon the temperature and fluidity of the zinc, and the careful straining from the fluid metal. The two analyses here given, were made by the writer a number of years since:

Zinc	94.27	94.15
Iron	5.46	5.00
Lead	0.27	0.56
Tin	trace	0.29
	100.00	100.00

These samples were taken from a remelting of a large quantity of the alloy, which is the only practicable method of obtaining a fair average specimen.

The quantity of this dross or refuse is quite considerable, amounting probably, in the United States, to several hundred tons per annum. Formerly it was sold for use in coarse brass castings, and to some extent it was re-distilled. At one establishment in Boston, circular clay retorts, similar to those in use in the gas manufacture, were employed, the molten alloy being introduced through an inverted siphon in the iron mouthpiece and the condensing tube connected with the reverse end of the retort, dipping in a pot of molten zinc; thus all access of air to the interior of the retort was prevented, and little or no oxidation of the zinc occurred.

Several years since, a small lot of this refuse zinc was received at a metallurgical establishment in Massachusetts, in which the writer was employed as chemist, and in experimenting upon it, one of the foremen of the establishment originated a method by which the zinc could be obtained quite free from iron. Finally, after rebuilding his furnaces and in various ways altering and modifying his manipulations, the samples of purified zinc being analyzed after each alteration of the process, a good commercial article was obtained, containing only $\frac{1}{10}$ of one per cent. of iron.

The process consists in melting the refuse in an iron kettle, raising the heat nearly to the point of volatilization of the zinc, and then, by a proper regulation of the heat, cooling the mass slowly from the bottom, by means of a special arrangement of flues. An alloy of zinc and iron, containing a much larger percentage of iron than the original refuse, gradually forms, falls to the bottom of the kettle, and is removed by a perforated ladle, while the fluid metal is much purer. The quantity of alloy to be ladled out depends upon the impurity of the original refuse. The purified zinc and the concentrated impurity are melted in separate kettles, and each treated as in the first operation.

One more fusion and refrigeration of the purified zinc and the still more impure zinc, renders the former a good commercial spelter, and the latter too impure for further economic treatment.

This process is the reverse in its reactions, from Pattison's process for desilverizing silver-lead ores. In the latter case the purer lead crystallizes from the more fluid lead and silver, whereas in the former the more impure alloy separates from the purified zinc.

The residue from this process, which is sold for distillation, consists of hexagonal prismatic crystals of a fixed alloy of iron and zinc, loosely agglomerated together so as to crumble in the hand.

When the operation of refining is badly conducted, more or less zinc acts as a solder for the crystals. They are beautifully iridescent, exhibiting all the colors of the rainbow, owing to a surface oxidation. A number of specimens of various

colors were selected for analysis and showed a composition of—

Zinc	90.50
Iron	9.50
	100.00

Upon fusing these crystals, which requires a high temperature, and cooling as before, a small percentage of purified zinc is obtained, and an alloy containing as much as 12½ per cent. of iron. This is compact, somewhat brittle, and exhibits no evidences of crystallization.

This last-mentioned fusion is not made in practice, as the great heat required for its accomplishment rapidly burns out the iron kettles.

By a similar process lead has been removed from zinc with great accuracy, the amount obtained closely approaching the quantity therein. From a lot of Silesian spelter was separated lead perfectly malleable, and containing scarcely a trace of zinc. The purification of the lead, obtained from the process of desilverization of silver-lead by means of zinc, could undoubtedly be accomplished by a modification of this process.

THE WATER SUPPLY OF PARIS.

From "The Engineer."

Paris presents some facilities, but more difficulties, as regards water supply. The city is surrounded by heights which present good positions for the establishment of reservoirs; but the sources of supply at hand are insufficient, and good water a long way off. The water brought by certain canals is not potable, so that it has been necessary to make separate arrangements for the supply of the inhabitants and the watering of roads and irrigation of the parks and public gardens.

The supplies are obtained partly from rivers and partly from springs. The former are supplied by the canal of the Ourq, which yields 105,000 tons; steam pumps on the Seine at Port à l'Anglais, 6,000 tons; ditto, at Maison Alford, 8,000 tons; ditto, at Quai d'Austerlitz, 22,000 tons; ditto, at Chaillot, 38,000 tons; ditto, at Autuil, 3,000 tons; Neuilly, 5,000 tons; Saint Ouen, 6,000 tons; the hydraulic works of St. Maur, 15,000 tons; giving a total of 208,000 tons.

Practically, however, this supply is greatly reduced by various causes, such as drought, which causes that of the canal of the Ourq to fall to 95,000 tons, repair of the machinery, etc.; so that the average that can be counted on safely is not more than 170,000 tons. Lately, however, the suply of the St. Maur works has been raised to 40,000 tons, so that an approximative total of about 200,000 tons has been reached. The spring water is derived from Arcueil, which yields 1,000 tons; the artesian well of Grenelle, 600 tons; the artesian well of Passy, 8,000 tons. In addition to these the waters of the Dhuis, which recently supplied 24,000 tons, have lately been increased to 49,000 tons by the construction of secondary aqueducts.

The distribution of these various supplies is a follows: The waters of the Ourq serve five arrondissements in the centre of Paris and the lower portions of ten other departments, as well as a part of the Bois de Boulogne. The waters of the Dhuis are reserved for the private service of three arrondissements in the outer circle of the city and of the higher portions of four other arrondissements. The waterworks of St. Maur supply the Bois de Vincennes. The water of the Seine raised by the pumps at Chaillot supplies the Tuileries, the houses of the ministers, the hospitals, the higher portions of old Paris, and a large portion of the outlying districts on high ground. The other waterworks serve their respective districts.

The Passy artesian well supplies the Bois de Boulogne; the water is hot, and loaded with sulphuretted hydrogen, like that of Harrowgate. The waters of Arcueil and of the artesian well of Grenelle are used to supplement the waters of the Seine.

At present the outlying quarters of the city—those which were but recently taken within its limits—are the best supplied with water; nearly all that of the Dhuis, besides that of the Seine, taken above the city, being reserved for this purpose, while the central and older parts of Paris are scarcely better off than they were in 1856, when the distribution only amounted to

80,000 tons. This latter fact has its origin in a variety of causes: in the first place, since 1857 the drought has been greater than ever occurred during the seventeenth, eighteenth, and nineteenth centuries; many sources have been completely dried up, and the yield from others has been diminished in an extraordinary degree. As regards the Seine, the conduit pipe of the water-works at Chaillot, which was established according to low-water mark in 1719, became quite uncovered towards the end of 1865, and the city was deprived at once by that occurrence of 38,000 tons of water per day, and that not only at the driest part of the year, but when a terrible epidemic demanded a double supply for the purpose of cleansing the streets. So large a deficit rendered it impossible to flood the gutters or water the streets, while the refuse lay stagnant in the sewers for want of current; the fountains and hydrants were without water during the summer, and Montmartre, Belleville, and Menilmontant were short of water all the season. The terror caused by the presence of the cholera under such circumstances gave the necessary impetus for insuring the increased supply of water to the capital.

Moreover, the number of the inhabitants of Paris is not only increasing every day, but new parks, gardens, and squares are growing up, and will require more water; lastly, there are 3,000 hydrants in the streets which are closed during the summer for want of water.

The quantity of water required for the future supply of Paris is set down at 420,000 tons per day, and the works now under hand are intended to bring it up to that figure. Of this total, 250,000 tons are required for the public service, watering roads, streets, paths, and grass, flooding gutters, sewers, etc., for which purpose no special quality of water is required. Of the remaining 170,000 tons, 40,000 are required for manufactories, and this may be taken from the Seine and the Marne, which falls into the former just above the city.

The 130,000 tons thus left for domestic use should be water having special qualities. The waters of the Ourq and of the Marne are too hard, and anything but agreeable to the palate; the water of the Seine is frequently muddy, besides being too warm in summer and too cold in winter. Spring water alone furnishes the necessary conditions, and this is the reason for bringing the waters of the Dhuis and the Vaune to Paris.

The Dhuis water arrives in the reservoir of Menilmontant at Paris at an altitude of 354 ft., and a portion of it is then pumped up into the reservoir at Belleville, 436 ft. high, for the supply of the high grounds of Montmartre, Belleville, and Menilmontant. The Vaune waters will be received in large reservoirs having an altitude of 244 ft.

Of the 59,000 houses and manufacturing establishments now existing in Paris, about 26,500 pay for water laid on to the premises, leaving 22,500 to be so supplied. The former consume at present 80,000 tons. When all are supplied, taking two millions of inhabitants, which the city is fast approaching, as a basis, each house, on an average, will receive more than 17 gallons of water per diem, or 26 tons per annum, at an expense of 4s. a year, or less than 1 ton of filtered water purchased of the water carriers, as is still the practice in all the houses to which water is not yet laid on. Ten francs a month is, under the latter circumstances, a moderate sum for a family to pay for water.

Under these considerations of the present and future wants of Paris, the municipal authorities caused a careful examination to be made of the means of supply, the result of which was the choice of the source of the Vaune with its tributaries for the completion of the supply of the city. The Vaune is a small stream which takes its rise in the department of the Aube, at Fontvaune, so named from the source, near Estissac, on the edge of the chalky plains of Champagne, and about 8 miles from Troyes. Its direction is from east to west, and it receives seven tributary sources before it falls into the Yonne just above the town of Sens. One of the reasons why the choice fell upon the Vaune was the remarkable constancy of its stream. Its basin, which is equal to nearly a thousand square kilometres, is entirely formed in the white chalk, but the plateaux are crowned with tertiary strata, formed generally of red mud mixed with loose stones. The plateaux are broken up, and the chalky slopes are bare, as is usual in Champagne. The valley is large and flat, and composed of very wet, marshy

land. The water is remarkably limpid. The Dhuis was far from presenting such advantageous conditions. Its sources were originally invaded by torrents, and cost much labor to preserve.

All the sources of the valley of the Vaune have been purchased by the city of Paris. They amount in all to thirteen, and are all on the left bank of the stream. Besides the sources, the city had to buy the factories and establishments most injured by the taking of the water. The first source is that of Cerilly, or Bûne. It springs out of the ground at an altitude of 460 ft., and its waters are so limpid that the bottom is clearly seen in a deep gulf. The water of the other sources is of equally good quality. The altitudes of the nine sources vary from that already given to about 290 ft. The water of all these sources will have to be lifted by machinery into the main aqueduct.

It has already been stated that the water of the Seine is too warm in summer and too cold in winter; and water, when too cold, not only gives rise to interruption in the service by freezing in the pipes, but may be the cause of grave disorders and inconvenience. The experience of ten years has proved that the Arcueil has an average temperature of from 50 deg. to 54 deg.; during the great heats the Dhuis water arrives in Paris at a temperature of about 56 deg. The waters of the Vaune will arrive in Paris completely aerated by an aqueduct open to the air throughout an extent of about 90 miles.

The water of the Seine will eventually only be used for manufacturing purposes, the quantity of organic matter in that river being too large to render the water fit for domestic purposes.

The works of the aqueduct present many features of importance. In the first place, each of the upper sources has to be conveyed by means of a secondar aqueduct to the main one. Between Thiel and Malhortie the aqueduct is carried on arches over the valley. From the latter place the line follows the chalky slopes of the right bank of the stream, passes to the right of the town of Sens, and enters the valley of the Yonne, skirting its right flank to a little below a place called Pont-sur-Yonne. Thence it is carried across the valley by means of a great siphon, and is continued to Moret, on the slopes of the Seine, without any serious difficulties. It then crosses the valley of the Loing, and enters the forest of Fontainebleau.

Here the most serious difficulties arise, on account of the composition of the soil, which is formed of sand, lying higher than the plateau composed of the argillaceous millstone which stretches thence to Paris. It was necessary to cut deep trenches and to form tunnels, one of which is very long; fortunately, however, there is no water here, or the work would have been almost impossible. After quitting the forest the aqueduct starts at the sandy hills, crosses the valley of Ecolle, and at Champteuil touches the argillaceous plateau, which it follows till it reaches Paris. Passing over the rivers Essonne and Orge, the aqueduct enters the valley of the Bièvre, and reaches Paris at the plateau of Montrouge, near the Orleans road, after a course of 89 miles.

The aqueduct is calculated to yield at least 258 gallons per second, its maximum being 324 gallons. The cost of the work will be about £1,160,000.

The reservoir is constructed in two stages; one of these, with an average depth of 11 ft. 8 in. of water, will contain about 123,000 tons, with a maximum altitude 262 ft.; the second, with a depth of 18 ft., will hold 182,000 tons, with a maximum altitude of 248 ft. Four conduits will carry the water from the aqueduct; two of these, 32 in. in diameter, will supply the upper, and the other two, 43 in. in diameter, the lower reservoir. The cost of this double reservoir is stated to be about £200,000. The whole cost, therefore, of bringing the waters of the Vaune to the edge of Paris ready to be turned into the mains will be about £1,360,000, and it would be difficult to find an instance of money better employed.

Wire Cable Towage. — The "Société Centrale de Touage," which has its seat in Brussels, has lately made a satisfactory experiment as to the practicability of introducing wire cable towage on the Rhine. The great advantage of the system is the saving of coals effected by the use of the cable, which is calculated at 75 per cent., the great objection to its general adoption being the difficulty of moving the vessels thus towed, out of the way of other ships.

TRUE BASIS FOR THE CONSTRUCTION OF HEAVY ARTILLERY.

By LYNALL THOMAS.

The essential point to be considered in the construction of a cannon (especially a rifled cannon firing cylindrical shot and heavy charges of powder) is the general effect produced in the gun by different charges.

In the opening chapter of Col. Boxer's well-known Treatise on Artillery, the author has pertinently remarked that "the force and effect obtained from gunpowder is the foundation of all other particulars relating to gunnery." A true knowledge of its force and action is therefore indispensably necessary, since without it no gun can possibly be constructed on sound principles.

More than ten years have passed since I first attempted to introduce a new system (based upon actual experiment) for heavy artillery.

It was entirely opposed to all existing theories or received opinions on the subject; and although at no period have so many gunnery experiments been carried on as during the interval referred to, none of the results of these experiments have tended to cast any doubt upon the truthfulness of the views I first put forward.

I am induced again to bring forward the subject, chiefly with the view of defining more clearly the principles upon which this system is based, and in what respect it materially differs from the system or theory which has hitherto been accepted as the true one.

The last-named theory was first promulgated about a century ago by Robins (who may be styled the father of modern gunnery, as he was the first who elevated it to the rank of a science), and is based chiefly upon experiments made (on the force and action of gunpowder) with a musket and small quantities of powder. It teaches as follows:—That "gunpowder fired in any space acts nearly in the same manner as a quantity of air would do which was condensed a thousand times more than the common air we breathe, and which in that condensed state filled the same space that was taken up by the unfired powder." (Robins's "Tracts on Gunnery," Prop. i. p. 219, Hutton's edition, London, 1805.)

Upon the above most untenable proposition the whole theory of modern gunnery is based!

In all works of gunnery therefore we find it assumed:—

1. That the whole of the charge of powder is converted into an elastic fluid capable of exerting a finite pressure only, the limit of which it attains before the projectile is sensibly moved from its place. (Dr. Hutton gives it as his opinion that the combustion of the charge is gradual; but in his various *formulæ* it is not supposed to be so.)

2. That the fluid exerts an equal pressure, estimated at so many atmospheres (but as nearly every experimentalist has assigned a different value to the initial pressure of fired gunpowder, it is impossible to say exactly how many), upon the shot and upon the sides of the chamber or portion of the bore of the gun which contains the charge. (This virtually supposes that the fluid evolved from the fired powder is *contained* in the chamber of the gun.)

3. That the value of the initial pressure is constant in guns of every calibre, and with any quantity of powder.

4. That the pressure upon the shot in its passage out of the gun is in the inverse ratio of the spaces occupied by the fluid (assuming thereby that the temperature of the fluid remains always the same).

5. That the movement of the shot through the first spaces is a slow one, and that the larger the calibre of the gun (the weight of the powder and projectile being proportional) the slower is the movement.

6. That the strain upon the gun is not affected by the weight of the projectile; and when in practice this is found not to be the case, the most absurd reasons are assigned for it; and the same may be said with regard to the observed variations in the initial pressure of different quantities of powder. The latter has even been attributed to a variation in the length of the gun. ("Hutton's Tracts," vol. iii. p. 296.)

7. That the pressure being constant in value, shot of every calibre fired with proportional charges of powder must pass through equal spaces (in calibre) before

they can acquire a given velocity. (According to this law, therefore, guns of all calibres ought to be of the same relative proportions (in calibres). — "Hutton's Tracts," vol. iii. p. 313.)

It is almost needless to remark that the above (which may be called the atmospheric pressure) theory is entirely at variance with experiment, a fact which renders all the more remarkable the tenacity with which it has been adhered to.

It was this discrepancy between theory and experiment which first led me to carry out a series of experiments with the view of discovering, if possible, the cause of it.

These experiments soon removed all doubt as to the nature of the action of fired gunpowder. It was clearly *impulsive*, or *percussive*, acting upon the shot and sides of the containing chamber in the manner of a blow, starting off the former, at once, with a considerable velocity, proportional, in a certain ratio, to the quantity of powder employed.

This simple fact at once destroyed the value of nearly every formula in use; and it is strange that whilst several well-known writers appear to have casually remarked the percussive nature of fired powder under certain circumstances (as in the bursting of guns), no one seems to have considered that it in any way affected, or to have applied it to, the action of an ordinary charge of powder.

Several scientific men of eminence have attempted, from time to time, to determine the value of the force of gunpowder, but with apparently very little success, since they have variously estimated it at from 1,000 to as many as 100,000 atmospheres; in fact it was found to vary with the different conditions under which the experiments were made. It will be easily seen, therefore, how impossible it is to construct a gun of correct proportions, or to determine the proper charge to be used with it, by the old theory. Consequently, up to the time when rifled ordnance were first introduced, all guns were constructed of the same relative proportions, those of a 68-pounder being similar to those of a 9-pounder gun.

But although it may be said to be impossible to assign even an approximate value to the force of gunpowder, it is not difficult to ascertain the *relative* value of the strain produced by different charges, fired under similar conditions, in guns of different calibres; and for practical purposes this is all that is required to be known.

The results of my numerous experiments have enabled me to arrive at the following conclusions with respect to the action of gunpowder and its effect upon the gun:—

1. That the whole charge of powder does not undergo complete conversion into gas before the shot is moved.

This important fact will not be disputed, as it has been already recognized by nearly every writer on the subject. Dr. Hutton has repeatedly assigned, as one of the causes of the discrepancies between the results of theory and those of experiment, the erroneous assumption that the whole charge was instantaneously fired. It will not be necessary for me to support this point by any further argument; some years ago I seized the opportunity of so doing, and my views upon the subject have since been fully appreciated by every artillerist.

2. The second proposition that is maintained in the treatise is, that the first action of the powder upon the shot is in the nature of an impulse of greater or less magnitude, dependent upon the quantity and the quality of the powder used, as well as on the position of the point from which the charge is fired.

That portion of the charge which has been converted into gas, impinges with a terrific velocity upon the shot, and begins to expel it before the whole of the charge is completely consumed or its force fully developed.

The action of this portion of the powder has been above denominated the first or initial action; and these words will be used in this sense throughout the rest of the treatise. The velocity imparted to the shot by this portion of the charge may be properly called the initial velocity.

These words are generally used to signify that velocity which the projectile has when it issues from the muzzle of the gun; here, however, they are used to denote that velocity which the shot has in the very beginning of the motion, viz., that with which it leaves its position of rest.

The word impulse is used in its popular and natural sense, to denote a force which generates a finite velocity in an indefinitely short period of time. In fact, the whole time that elapses between the ignition of the charge and the expulsion of the

shot from the piece, is scarcely sensible; yet it can be subdivided into intervals that bear some ratio to one another. In one of these intervals a portion of the charge has been fired, and a certain velocity has been simultaneously imparted to the shot; in the other interval the remaining part of the powder has been consumed, and the shot has been moved through the piece. The initial action of fired gunpowder is thus said to be impulsive, because it produces motion in the projectile before the whole charge has been completely converted into gas. The position of the vent is a matter of some importance. If a charge be ignited at the extremity nearest the shot, the violence of its initial action upon the shot will be diminished; but its action in the direction of the breach will be considerably increased.

There is nothing in this theory at variance with observed facts; on the contrary, it affords a clear explanation of many otherwise inexplicable results, and furnishes a simple and intelligible law for the construction and use of ordnance, whilst the atmospheric pressure theory, being altogether irreconcilable with facts, abounds consequently in those paradoxes occasionally quoted by officials with a kind of triumphant air, as affording convincing proof of the utter hopelessness of any attempt to find a law for the action and force of different charges of powder fired under various conditions.

Equal charges, fired under similar conditions from guns of a given calibre, invariably produce the same results. When, therefore, in practice, results are occasionally obtained which cannot be reconciled with the atmospheric-pressure theory, it is clear that the theory itself is faulty; since it is not probable that a charge should act in an eccentric manner on particular occasions without some cause being assignable for it.

The errors which are traceable throughout the atmospheric-pressure theory may be likened to so many rotten strands in an otherwise sound rope, which render necessary its complete reconstruction before proper reliance can be placed upon it.

We now proceed to show how these conclusions may be employed in calculating the strain exerted on the gun.

In the first place it must be observed that whilst the shot is traversing the initial space, the rest of the charge is undergoing complete conversion into gas; and when such conversion has taken place, the gas rushes forth in the direction of the axis of the bore. A considerable portion of this gas is driven into, or, more properly, condensed in that space that has been just vacated by the shot; and at this important instant the gun is called upon to sustain the greatest possible strain that is exerted upon it. If the gun be of sufficient strength and thickness to endure the disruptive power of the charge, the chief effect of the intense pressure will be directed towards the removal of the shot.

From the above explanation it will be seen that, in order to be able to calculate the different degrees of tension for different guns, we must first endeavor to investigate the mathematical relation subsisting between the initial velocity, the weight of the shot and of the charge, and the diameter of the bore. As soon as we have determined in what manner the velocity depends upon these known quantities, we shall be able to express in terms of them the volumes into which the gas is condensed; and then it will be seen that the relative strains exerted upon different pieces can by an easy process of mathematical reasoning be expressed as algebraical fractions of certain known quantities.

Having arrived at the above conclusions, my next object was to ascertain, by a series of experiments, in what way the initial velocity of the shot varied with a variation either of its own weight, or of that of the powder employed, or of the weight of both of these. For this purpose I caused to be constructed a series of cylindrical chambers, of different diameters and depths; these were sunk in blocks of the best metal, and when fired were filled with the powder generally used. The shot was spherical in shape, and was placed gently and evenly on the top of the chamber. The vertical distances traversed by them were in every case accurately measured by means that I need not proceed to explain. I observed that the velocity of projection was entirely due to the initial action of the charge, and was in no way altered by the subsequent explosion of that portion of the powder which was fired after the first movement of the shot.

In order to convince myself of this all-important fact, I caused the shot to be

raised by a hair's breadth above the top of the chamber; and when in that position the fired charge produced a motion that was barely sensible, and when the shot was elevated by something less than $\frac{1}{8}$ in., no movement of any kind was observed on the charge being fired.

These experiments showed that the velocity initially imparted to the shot was not increased by the blast of the powder it had left behind; and therefore the vertical spaces described were then due to the velocities of projection.

It is unnecessary for me to give my experiments in detail; in fact, the limits of this short pamphlet forbid me so doing. I need only state that after laboring for several years, and varying in every possible way the relative weights and dimensions of the powder, the gun, and the shot, as well as the circumstances under which they were fired, I found the following laws to hold invariably:

1. That when shot of the same weight and size were subjected to the action of different quantities of powder, fired in chambers of the same diameter, the initial velocities communicated to them were directly as the square roots of the weights of the charges employed.

2. That when shot of different weights were placed upon the same chamber, filled with the same quantity of powder, the initial velocities were inversely as the square roots of the weights of the shot.

3. That when shot of different weights were subjected to the action of different charges of powder, fired in chambers of different depth, but of the same diameter, the initial velocities were directly as the square root of the weight of the powder, and inversely as the square root of the weight of the shot.

4. *That when the diameter of the chamber was increased, the initial velocity was increased (with proportional charges) in the ratio of the square root of the diameter.**

The above laws are based upon the results of innumerable experiments. At the time when I first began to examine the initial effect of gunpowder, I had no particular theory of my own to uphold, but was anxious to investigate in a truth-seeking manner the cause of those wide and seemingly unaccountable discrepancies between the conclusions derived from Robins's theory and the results of experiment. I was, in the beginning of my labors, rewarded with the discovery of (what I had previously taken to be) the real nature of the action of the fired gunpowder. I do not lay any great stress upon the fact that the charge is gradually ignited, as this has been affirmed by every writer on gunnery; but it is the application of this principle, for the purpose of investigating the strain exerted upon the gun, that seems to have escaped Hutton, Rumford, and others. That the initial action of gunpowder is impulsive, or, in more intelligible language, that the shot is sensibly moved before the whole charge is inflamed, is the great proposition that lies at the foundation of the present theory.

After I had gone through a short course of experiments, I was induced, by the apparent invariable uniformity of the action of gunpowder, to frame a few laws for the purpose of establishing formulæ upon which subsequent calculations might be based. I was enabled to test and to rectify the laws that I had first formed, until ultimately I arrived at those very expressions which theoretical investigations declare to be founded on truth.

I now proceed to investigate certain algebraical expressions for the pressure and tension, founded upon the above laws. Let L denote the length of the shot (*suppose cylindrical*),

d denote the diameter of the bore,

W denote the weight of shot,

L′ denote the length of cartridge,

W′ denote the weight of cartridge,

the point of ignition being the same in each gun.

Now by the fourth law* the initial velocity varies as

$$\sqrt{\frac{W'd}{W}}$$

And as we purpose to calculate the relative strain only, we may take this to represent the initial velocity.

* All who know any thing of the action of gunpowder are aware that the effect produced by the combustion of a given quantity, when spread over a large surface or formed into a long train, is very different from that which is produced by the combustion of the same quantity placed in a heap, or in as small a compass as possible. It is not difficult, therefore, to imagine that the initial effect produced on projectiles by powder confined in a different form may be different.

* By the first law, if the length of the cartridge be varied, the initial velocity varies as $\sqrt{W'}$; by the second law, if the weight of the shot be varied, the initial velocity varies as $\sqrt{W}$; and by the third law, if both these quantities be varied, the initial velocity varies as $\sqrt{\frac{W'}{W}}$.

The volume that is vacated by the shot may be written

$$\sqrt{\frac{W'd}{W}} \times d^2.$$

Into this volume a certain portion of the gaseous fluid is condensed. This portion varies as $L'd^2$, i. e. as W'. Thus the pressure that is impressed upon that part of the piece that has been initially traversed by the shot, will be as

$$\frac{W'}{\sqrt{\frac{W'd}{W}} \times d^2}, \quad \text{i. e. as} \quad \sqrt{\frac{WW'}{d^5}}.$$

The degree of tension * of the gun-metal will therefore be expressed by

$$\sqrt{\frac{WW'}{d^5}}$$

This formula was found to accord in every way with the results of my experiments.

It measures the disruptive tendency of the charge, and will enable us to show how the thickness of the metal must be increased in guns of different calibres, the proper quantity of metal having been acquired in the first instance for a gun of given calibre, as in the case of the 7-inch gun for instance.

It would appear, then, that by sufficiently increasing the thickness of the piece it would be rendered strong enough to support the charge that it was intended to carry, and that the danger of its bursting would be entirely obviated. This, however, is not true; at least it must be received with some caution.

Whilst I was engaged in making my experiments, my attention was constantly being directed to the fact that the interior surface of the piece generally exhibited signs of great distress, whilst the exterior surface appeared to be as safe and as firm as ever. In fact, I frequently found that a gun might be burst by a charge that it had frequently sustained, but which by having been repeated had encroached upon the inner surface so as to undermine completely the original strength of the piece.

* It is known that if a gas be contained in a cylinder, the tension at any point in the curved surface of the cylinder depends upon the radius of the cylinder as well as upon the pressure of the gas. And in fact if p denote the pressure of the gas and r the radius of the cylinder, the tensional force is pr. In the above we have taken it to be pd; this will make no difference, as we are concerned only with the relative magnitudes of the different quantities.

The portion of the bore that appeared to have suffered more severely from the action of the powder, was that immediately about the base of the shot; in fact that part through which the shot had initially moved, and which, from what has been said before, was called upon to endure the greatest bursting power of the gas.

The following might be offered as an explanation of this fact:

The pressure which the inflamed charge exerts upon the surface of the bore produces a strain throughout the thickness of the metal. This strain is transverse to the axis of the bore; and its effect would be to sever the cylinder along one or more of its generating lines. Should this disruptive force be held in check by the thickness and strength of the gun-metal, no sign of any stress will be discernible upon the exterior of the gun. But with the interior surface the case will be different, since the gas in its efforts to escape through the thickness of the piece has been grinding that layer of the metal (in immediate contact with it) against the layer immediately above.

Thus it would seem that the corroding effect, as it may be termed, of the charge upon the inner surface of the gun depends upon the intensity of the pressure.

Now this pressure has been before shown to equal

$$\sqrt{\frac{WW'}{d^5}}.$$

If we put for W and W' their proportional values Ld^2 and $L'd^2$ respectively, the pressure is made to depend upon

$$\sqrt{\frac{LL'}{d}}.$$

It will be seen on reference to the expression for the tension that the weight of the shot considerably affects the strain upon the gun. And no one who has ever made any experiments in gunnery doubts that such is the case. This point has considerably perplexed artillerists who have been taught to place implicit faith in the well-known assertion of Robins, that the strain upon the gun is the same whether a ball be fired or not.

The great mistake committed by artillerists of the old school was in considering the bursting effect of the gas to be simply a statical force. In all their treatises it is assumed that the whole charge, having

been instantaneously converted into gas, pressed with equal intensity in every direction. Had such been the case the shot would have scarcely moved whenever the gun burst, the gas having escaped from the piece before it had had any time to generate velocity in the shot. Had the charge been instantaneously inflamed, the impulsive strain exerted against the sides of the chamber would undoubtedly have been of the same intensity, whether there was any thing to obstruct the subsequent passage of the gas or not. In this case the powder would have exerted its full effect upon the gun before it had time to relieve itself by expansion through the bore.

If, then, we take into our consideration the effect of the removal of the shot before the total conversion of the charge, we are led by a well-connected chain of reasoning to determine the manner in which the rest of the charge rushes towards the space that has been traversed by the shot. This space is of course already filled with the gas that was generated in the very beginning of the explosion ; and the moving power of the powder when wholly ignited condenses a considerable portion of the gaseous volume into this, comparatively speaking, vacant chamber. The quantity of gas so condensed has been above taken to vary as $L'd^2$, and the use of this expression involves no assumption whatever. For if I stood solely upon the results of my experiments I should be justified in counting it as such ; and theoretical considerations affirm the truthfulness of such an expression. The volume that would be driven forward in any time evidently varies as d^2, whatever be the length of the charge ; and since the whole body of the gas is moving in the direction of the axis of the tube, the intensity of the condensing force varies as L', the length of the charge.

The three formulæ that have been obtained by the principles enunciated in this pamphlet may be briefly stated as follows :

The initial velocity is given by $\sqrt{\frac{w'd}{W}}$, the tension or the bursting effect by $\sqrt{\frac{WW'}{d^3}}$, and the corroding effect of the pressure by $\sqrt{\frac{LL'}{d}}$.

The charges are supposed to be fired under the same conditions in each gun.

These formulæ will hold good whatever the quality of the powder used with, or metal employed in the manufacture of, the gun, unless, indeed (which is scarcely within the limits of possibility), a metal of an imperishable nature could be discovered wherewith to line the interior of the gun.

If the foregoing is (as I firmly believe it to be) correct, it is a most important fact, since (contrary to general opinion, which supposes that by doubling, say, a charge of powder the strain on the gun is doubled) it shows that to double the strain on a gun the *weight of the projectile* as well as the quantity of powder must be doubled.

Now, as the striking effect of shot of given form and calibre depends (at moderate distances) on the force with which they are projected more than upon their own weight, and if (as appears to be the case) the weight of the shot tends so considerably to increase the strain of the gun, a reduction in the weight of the shot and corresponding increase in the powder-charge might in most cases be attended with better general results. By proportioning the charge to the shot in such a manner that the product of the proportions of both shall never exceed a given quantity, the effect produced on the gun by the different relative quantities would be nearly the same. One of the great advantages attending the use of rifled cannon is the power of employing either a heavier charge and lighter projectile or the contrary, as occasion may require.

[TO BE CONTINUED.]

THE United States war sloop Yantick has been appointed by the American Government to make the soundings for the West Indian submarine cables from Jamaica to Porto Rico, St. Thomas, and Barbadoes. The British Admiralty have also ordered a vessel to continue the soundings from Barbadoes to Trinidad and Demerara. The Yantick is being fitted with sounding gear at the Navy Yard, Brooklyn, and will sail on the 1st of January, under the command of Capt. Irwin, United States Navy, by whom the soundings between Jamaica and Panama have already been made in the Gettysburg.

THE CLIFTON BRIDGE, NIAGARA.

By SAMUEL KEEFER, Engineer.

From "Engineering."

This bridge has been open to the public just one year, and the result has been most satisfactory. It has economized the time of transient visitors, and has been a great convenience to those who remain for any length of time; while to the stockholders it has yielded a large percentage on their outlay.

A fearful storm visited this part of the country in the latter part of November last, which extended, also, with more or less severity, over a great portion of this Northern continent, making its power felt by upsetting an iron bridge lately erected in Ohio, and blowing a whole train off the track on the New York and Harlem Railway, leaving nothing but the engine standing on the rails. Judging from its effects, it appears to have been quite as strong as the imaginary tempest referred to at page 301, vol. vii., of your journal, against which provision was made in the construction of the bridge.

My attention was first called to its effect on this bridge by a short paragraph in a Buffalo paper; and as soon as my time permitted I paid a visit to it to learn from the parties in charge the true nature and extent of the disturbance caused by the storm; and I trust that the following facts, gathered from their statements, may be considered of sufficient interest to find a place in your valuable journal.* Your readers, who have seen the account and illustrations of this work, which appeared in vol. vii. of "Engineering," pp. 287, 290, 300, and 301, will understand from these, and will fully appreciate, the endurance of so light a structure under such a very severe test.

The storm occurred on the 17th November, and raged 12 hours, from 9 o'clock in the morning to 9 o'clock in the evening. It gathered up its forces in the long sweep of Lake Erie, and struck the bridge nearly square upon its beam—the course being S. S. W., bearing hardest on the Canadian shore. It gradually increased in intensity until 1 o'clock, when there came a shock which, it is supposed, moved the two anchor stones on the S. W. quarter, to which the longest guys in that direction were attached, one weighing 9 tons, and the other 32 tons, pulling them from their beds, and rolling them over 10 ft. nearer to the bridge. This power, be it remembered, was exerted by a small wire rope, only $\frac{5}{8}$ in. in diameter, and of an ultimate theoretical strength of only 10 tons. By the loosening of these two ropes, and of another on the S. E. quarter, in a similar manner, more play was given, and the wind had more effect upon the platform; but from 1 o'clock until 4, the disturbance was not so great but that foot passengers and carriages continued to cross, although with much difficulty in making head against the wind. During this time the wind acted by impulses. It would lull for a time, and then return with greater fury than ever. At 4 o'clock it had reached its greatest strength, when the longest guy on the S. E. quarter gave way at the fastening, and then followed, in quick succession, first all the guys on the S. E., and then all the guys on the S. W. quarter, up to within 200 ft. of the land.

Altogether, the platform was held in place by 58 guys—30 on the upper or windward side, and 28 on the lower side. 21 of those on the windward side gave way, including the three before mentioned as having dragged their anchors, leaving only 9 still holding on that side, and extending out, as before stated, 200 ft. from either end. As the guys on the leeward were slackened by the yielding of those on the windward side, none of them were broken. The middle of the bridge immediately canted over about 3 ft. to leeward, while, the platform being fixed at both ends, there was accordingly that much twist in the framework. The canting of the bridge exposed it more directly to the action of the wind, and thereby caused the cables to swerve so much more from their true positions. The cradle form of the system accounts for this disturbance of the level, for as the one to windward rises, the other, being linked to it through the platform, must necessarily fall, and thus throw the bridge so much out of level.

* It is from an intelligent consideration of such facts as these that an engineer learns how to build.

So it will be seen that, after the partial yielding of the guys, the platform was exposed directly to the action of two disturbing forces—first, the weight of the guys on the leeward side, and second, the horizontal pressure of the wind. These forces were met by two others that belong to the bridge—first, the inherent strength and stiffness—the whalebone toughness of the framed roadway—and, second, the weight and strength of the cables, their weight coming in play the moment they were swayed from their normal positions. The weight of the leeward guys alone was sufficient to depress the lower side 10 in., and the guys and the power of the wind together canted it about 3 ft., as before stated.

The vertical undulations of the roadway, after it had been exposed in this manner to the full fury of the wind, did not at any time exceed 18 in. This, for so long a span, and so light a structure, must be considered a very moderate departure from the true curve. It must be directly attributed to the beneficial effect of the small hollow studs introduced between the cables and the roadway at intervals of every 50 ft. from the centre, while at the centre the cables themselves bear directly upon the platform. By this arrangement the weight of the central portion of the cables for 400 ft. becomes an insistent weight to keep the bridge from moving; and the cables themselves, weighing 81 tons, cannot easily be thrown into an undulating motion, more especially as they are checked, each of them by four bridle stays.

At four o'clock the gates were closed against carriages, and were not opened again until nine, when the storm had completely subsided. As soon as it was over, the platform returned at once to within 10 in. of its horizontal position at the centre, and although the bridge was out of line, carriages could cross it again as usual.

The framework of the roadway did not suffer the slightest injury during the storm, and not a single timber, plank, or bolt was broken or displaced. Moreover, strange as it may seem, not a single wire rope of any kind about the bridge was broken (a fact much to the credit of the makers); it was only thin fastenings that failed. Owing to the bad quality of the iron, some of the ring bolts in the chord above, and some in the rocks below, were broken, while in other cases the rocks moved, or, being loosely stratified, treacherously yielded to the strain. Nor did any socket fail. The only instance of a rope giving way in a socket, was in one of the bridle stays, and this, upon examination, proved to be unskilfully made. All repairs were promptly made, with stronger fastenings to the guys, and I found the bridge in perfect line, in good condition, and, if anything, more secure than ever against accident. During the worst of the storm the towers stood as firm as a rock. The foreman in charge ascended to the top in the afternoon, and could not perceive the slightest vibration.

Altogether, I have reason to be proud of the manner in which this bridge withstood the trial, and I may remark that the fact of its having escaped with so little injury has inspired more confidence in those who are in the daily habit of using it. It suffered much less than Telford's Menai bridge during a similar storm some years since. On that occasion, it will be remembered that the platform was broken up, and part of it carried away.

I may now point out three features in this bridge, which, in conjunction with the guys, materially contributed to its safety. First, the hollow iron studs (gas-pipe) between the cables and roadway at the centre of the bridge, causing them to move together as one. Secondly, the bridle stays serving to check the vertical vibrations in the cables; and thirdly, the rolled iron bars fish-plated together under the lower chord of the side truss, forming, as it were, a continuous chain from end to end of the platform. Without this iron chain the wooden chord would have been pulled to pieces. In order to check the action of the wind on the centre of the bridge, two small steel wire ropes are to be tightly strained from cliff to cliff, crossing each other at nearly right angles under the centre of the bridge. When under strain, the bridge is to be attached to them in such a manner as to give it an initial power of 10 tons to meet the force of the wind, the moment it begins to disturb the condition of repose. Up to that moment the strain is on the rope, not on the bridge, and after that there is a power of 50 tons to keep the bridge from vibrating more than 10 in., while the vertical play of 3 ft. due to changes of temperature, produces no sensible effect upon the braces.

INTERESTING ESTIMATES ABOUT THE SUEZ CANAL.

From "The Financial Chronicle."

In France, the "Messageries Imperiales" are adapting some of their fine steamers for the canal. A number of light-draught steamers are building in England for a similar use, and docks and warehouses have been secured by the Russian authorities at Port Said for the use of the Great Commercial Company of Odessa, whose vessels will ply between that port and the East. The powerful and wealthy Austrian Lloyd has offered to carry free, samples of the national products, with a view to improving and extending the trade of Austria in the Indian seas; and the Italian Government has urged the shipowners of that country to prepare to profit by the opening of the canal. A steamship line is organizing in Spain to ply between Barcelona and the Philippine Islands; and in this country the Oriental Steam Navigation Company will soon establish direct communication with China, India, and the Mediterranean ports. As a general summary of the commercial movement, M. de Lesseps estimates the tonnage of Liverpool at 6,000,000, and the trade through the Dardanelles 6,000,000, and claims that the traffic of the canal will be 6,000,000, affording from the tonnage alone an annual return of $12,000,000.

It is also claimed that the opening of the canal will favorably affect the commerce of the United States with the East. For the fiscal year ending June 30, 1867, our direct trade with the principal countries of the East, viz., Dutch East Indies, British East Indies, Australia, Philippine Islands, the South Pacific Islands, and China, was, total exports $14,606,809, total imports $24,780,097.

During the same period the total of exports to southern Europe, the Mediterranean, and the East Indies, was $71,780,203, and of imports, $65,394,796, in all $137,147,999; from which it will appear that $\frac{1}{8}$ of the foreign commerce of the United States was transacted with the countries named. How much of this trade will flow through the new channel, remains to be seen. The canal undoubtedly shortens the average distance between our Atlantic ports and the East, as will appear from the following table of comparative distances from New York and Port Royal to the principal ports of Australia and Asia, via Gibraltar and Suez on the one hand, and San Francisco and the Pacific on the other, measured in nautical miles, with the exception of the distance overland to the Pacific coast:

	From New York via Gibraltar and Suez.	From Port Royal via Gibraltar and Suez.	From New York via San Francisco & Pacific R. R.
Melbourne.....	13,200	13,700	10,300
Shanghai.....	12,500	13,000	8,850
Hong Kong....	11,700	11,100	9,300
Manilla.....	11,600	12,100	9,600
Singapore.....	10,300	10,800	10,600
Batavia.....	10,500	11,000	11,000
Penang.....	9,950	10,450	11,000
Calcutta.....	9,700	10,200	12,150
Ceylon.....	8,750	9,250	12,200

At a recent meeting of the Ethnological Society some photographs of the great megalithic monuments in Wiltshire were exhibited. We understand that a scheme is now in progress to obtain funds for the purpose of procuring a series of photographic representations of the megalithic monuments found in England and France, and, if possible, in Europe and Algeria. Such a series, in which the compass-bearings and accurate dimensions would be given, would be invaluable to the student in archæology. "Nature" says that any interested in the work who wish to know more of the details are requested to communicate with the Librarian, Royal Geographical Society, 15, Whitehall-place.—*The Engineer.*

Experienced engineers have stated that the cost of taking the London sewage to Sea Reach would greatly exceed the total cost of the metropolitan system of main drainage, and that the area requisite to utilize the sewage would not be less than 70,000 acres. We believe it appears in the evidence attached to Mr. Rawlinson's report, that, as compared with guano at £11 a ton, the annual value of the London sewage is not less than £1,000,000.—*The Engineer.*

IRON AND STEEL NOTES.

IRON ORE—SOURCES OF SUPPLY.—The iron interest in the West is increasing with greater rapidity than almost any other. Furnaces and rolling mills are being erected in Michigan, Wisconsin, Illinois, Indiana, Ohio, Kentucky, and Missouri. The demand for iron ore is rapidly increasing, and many of the old as well as most of the new works (even to a distance of 1,000 miles by water) are looking to Missouri for a supply.

The Iron Mountain and South Pacific Railroads are the only ones on which any considerable beds of iron ore are known to exist, accessible to this market. The present demand from the Iron Mountain is greater than its means of supply. The seven furnaces at Carondelet, when all in operation, will require not less than 200,000 tons of iron ore per annum. The contract now existing for iron ore, to be shipped to various points on the Ohio River, as far as Pittsburg, and to the interior of Indiana, will require nearly as much more—making an aggregate of 400,000 tons annually.

It is not within the capacity of Iron Mountain, Pilot Knob, and the Iron Mountain Railroad to furnish this supply. The demand for Missouri ore, present and prospective, is equal to the full capacity of tonnage on both the Iron Mountain and the South Pacific Railroads, and with rates the same as charged on the Iron Mountain for the same distance, if there were no difference in the quality of the ores. capital will be attracted to develop the iron in the new fields on the South Pacific. But as it is known among iron men that the red ores of the Southwest are more economical for all commercial purposes than the specular ores of Iron Mountain, or Lake Superior, or the hematites of Tennessee, it seems to us that the most inviting field for the investment of capital in the business of mining ores, at present, is in iron mines contiguous to the South Pacific Railroad. These mines are few in number, but so far as developed promise to be of the most extensive and permanent character. The ores yield more in the furnace, with the same amount of fuel, than any specular ores above named, and the product is equal in quality and for many purposes better than any other ores that can compete with them.

The ores of the Southwest are first met at Cuba, Crawford county, where two mines have been partially developed; next at St. James, where they have been worked very successfully for more than 40 years—and next in the vicinity of Rolla. In several of the beds the ore has been uncovered *in mass*, and specimens shown us from each, justify the conclusion that these deposits have been thrown up while in a liquid state, and thus cooled and solidified—giving the best possible guaranty of their inexhaustible character. In some of the Southwest mines the ore exists in boulders and detached pieces, in some instances running in lodes and veins.

The extension of the Pacific track to the river will greatly reduce the cost of transfer, and give a new impetus to the mining and shipping of the Southwest ores.—*St. Louis Journal of Commerce.*

THE TERRE-NOIRE IRONWORKS.—To those of our readers who have paid careful attention to the state and progress of iron and steel manufacture on the Continent, and particularly in France, the name of the Compagnie des Fonderies et Forges de Terre-noire, la Voulte et Besseges, will be well known and quite familiar, but to the generality of the British public and of engineers in this country and in America, the Terre-noire Company is less known than it deserves. As indicated by the lengthy title of this concern, the works are situated in three different localities, and they are managed from one head office at Lyons. The three separate works are devoted to different branches of iron manufacture, but the principal and most important works of this company are the steelworks at Terre-noire. These works were amongst the first licensed under Mr. Bessemer's patents in France, and have at present the largest production of Bessemer steel in that country. At the same time the Terre-noire Company are the most important licensees of Messrs. Martin in France, for the manufacture of Siemens-Martin steel, which is carried on very successfully and on a large scale at the Terre-noire steelworks.

The principal articles made at Terre-noire are steel rails and steel boiler plates. The raw material is produced on the spot in the blast furnaces of the Terre-noire Company, and from ores of such purity that the pig-iron can be regularly sent direct from the blast furnaces into the converters. This is the only instance known to us of Bessemer pig-iron smelted with coke being run direct from the blast furnace into the converter in regular practice, and it shows that the quality of the raw material must very nearly approach that of charcoal iron, which is usually converted into Bessemer steel direct from the blast furnaces in Sweden and in Styria. This superior quality of the raw material is unquestionably the first cause to which the Terre-noire Company is indebted as regards the quality of their steel, but the success is equally due to the care and attention with which this company has watched the progress of steel manufacture during the last period of transition, the intelligence and sagacity with which it has appropriated, and often even monopolized, every valuable improvement that has been brought out in this country or elsewhere, and the enterprising manner with which it has placed itself at the head of metallurgical progress in France. We may mention, for instance, that the Terre-noire Company has acquired a sole license for France from Mr. William Henderson for the manufacture of ferromanganese by his patent process, and having at the same time purchased the French patent of M. Prieger's invention for making alloys of iron and manganese, the Terre-noire Company is at present the only Bessemer steel works in France which employs rich artificial alloys of manganese for the manufacture of the softest kinds of Bessemer steel. Step by step, as valuable inventions are made in the branches of iron and steel manufacture, the Terre-noire Company has been trying, testing, and appropriating valuable improvements, and in an equal rate of progression it has spread the repute and the market for its products over the Continent, and even over England and America. There are steel plates from Terre-noire imported and purchased by some of the most celebrated boiler makers in this country, and the Terre-noire rails are the most formidable rivals of English Bessemer rails in the markets of Italy, Austria, and in America. The managing director of the Terre-noire Company is Mr. Alexander Jullien a gentleman whose professional standing is well known to many scientific men in this country, and to whom we believe belongs the principal merit with regard to the important fact that in a very short space of

time the Terre-noire Company has risen from comparative insignificance to the position of a leading steel manufacturing concern in France.—*Engineering.*

DEPHOSPHORIZATION AND CRYSTALLIZATION OF IRON.—Experiments, instituted with a view to the dephosphorization of the iron from the Königshutte furnaces (Prussia), were made by the introduction of chloride of calcium into the blast furnace, on the theory that chloride of phosphorus might thereby be formed and volatilized. It was, however, found that the chlorine was liberated from its combination at entirely too low a temperature to effect any change. The results in this country, where fluoride of calcium has been substituted for the chloride, have been much more encouraging, and a decrease in the amount of phosphorus has really been effected thereby, some of it probably passing off in the form of a fluoride. The Prussian iron above alluded to contains 0.497 per cent. of phosphorus, and produces a highly cold-short and brittle Bessemer steel. Refining in a reverberatory furnace, by means of jets of air forced down upon the surface of the iron, was tried, but led to no favorable result. On puddling the iron and re-converting to cast-iron in a cupola, the percentage of phosphorus was reduced to 0.1. But this re-converted iron was found to be dearer than Cumberland iron delivered at the Bessemer steel works in Silesia, and so this process was abandoned of a necessity. It was also found that iron, when treated in this manner, loses silicon, thereby unfitting it for conversion into Bessemer steel.

A remarkable instance of the crystallization of metallic iron was noticed recently, during an examination by Mr. Crookes, of the Heaton or nitrate of soda process for the production of refined iron. After the subsidence of the violent action which ensues when the nitrate of soda is in contact with the molten metal, the converter, or lower portion of the apparatus, is detached, and, after a few minutes, the contents are turned out upon the floor in the form of a porous mass, weighing nearly three-fourths of a ton. A careful inspection of this mass of somewhat refined iron showed it to consist of minute cubical crystals, segregating or arranging themselves in feather-like groups. The crystals are said to be sharp and well-defined, and to present an exceedingly beautiful appearance. Such phenomena are by no means uncommon on the gradual cooling of masses of other metals, but the instances in which they have been noticed with regard to iron are very rare. During a recent visit to the smelting works of a mine in Wythe county, Virginia, we were able to procure exceedingly well-defined and quite large cubes of metallic lead, while the production of crystals of bismuth and some other metals, by a method of slow cooling, is described in most works on chemistry.—*American Exchange and Review.*

ANVILS.—The face or table of anvils as at present made is often defective, having frequently hard and soft places after hardening, which face should be equally hard all over its surface, and the steel in some instances not being properly welded to the iron part or butt which forms the lower part, the anvil is thereby rendered unsound and not fit for use. Some improvements recently patented by Mr. J. N. Askham, of Sheffield, have for their object the removal of such defects, and consist in so making anvils that the face may be equally hard all over when finished, and in so casting or welding the butt to the head or upper table that the parts may be thoroughly amalgamated and the anvil made more durable at a less expense than hitherto.

Mr. Askham first prepares a model of the size and shape of the anvil to be produced. He then places it in a box, covers it with composition, and fills up the box with sand in the ordinary manner. After the model is removed and the sand perfectly dry (this being done in the usual way), he first pours in the molten steel to form the face or table, then, through the same aperture (after the steel on the table is sufficiently cool), he pours in a very mild molten steel, which flows over the table and gives the requisite toughness and solidity to the steel beck. After a proper time has elapsed, he pours in through another opening the iron or metal, which also runs upon the steel and forms the lower part or butt of the anvil, and a perfect amalgamation takes place between the iron and steel. The casting being complete, it is then finished in the ordinary manner for castings.

To harden the work, a large metal bosh or trough, 6 ins. or 8 ins. deep is formed, in which is inserted a number of perforated sharp-edged bars of metal, on which the anvil is allowed to rest on its face or upper surface, either flat or slanting. A sluice communicating with a reservoir of water is then opened, and a force of cold water is allowed to flow upon the face by an upward cast and to pass under the anvil and over the bars to any depth required. By these means a much harder and more regular surface is obtained than by the present mode of manufacture. After this the surface is ground in the ordinary way.—*Mechanics' Magazine.*

BESSEMER STEEL-MAKING IN FRANCE.—The total production of Bessemer steel rails in France in the first six months of this year amounted to 19,755 tons, against 10,562 tons in the corresponding period of 1868. It is probable that the French production of this description of rails will show a still further advance in the second half of 1869, as large orders have been given out during the last two or three months by the great French railway companies. Among the more recent orders of steel rails we may mention one for 2,000 tons given by the Orleans Railway Company to the Creusot Works, at £11 7s. 2d. per ton, and another for 3,000 tons, given by the Western of France Railway Company to the Terre-noire Works, at £11 10s. 3d. per ton.—*Engineering.*

RAILWAY NOTES.

MOUNT CENIS RAILWAY.—The Mount Cenis Railway is a work quite independent of the lines which the tunnel is intended to connect. It cannot possibly be called a rival scheme, but this railway contrasts most remarkably with the tunnel, and affords a complete solution of the difficulty of surmounting mountain ranges at a moderate cost; the practical results of the working of this line, which after all is merely an experimental and provisional one, must be considered by all who view it without prejudice, highly satisfactory.

Only three interruptions have occurred since it was opened, and none of them were from any

cause arising from the system itself. The first in August, 1868, was caused by tremendous floods, which ravaged the whole face of the country, and greatly damaged the chaussée on which the railway is laid. On this occasion the passage across the mountain was stopped for three days only, but was equally blocked for diligences and road wagons, and there was a further partial stoppage during ten days subsequently, when passengers and goods were transported in sledges for distances varying from two to ten miles. The second was in 1869, arising from snow storms and hurricane drifts. The third, in December last, was from similar causes, when the transit over Mont Cenis was never totally closed, but had for some days to be made partially by sledges, and, of course, considerable irregularity unavoidably resulted.

The concession for the Mount Cenis Railway limited the time of its duration to the period of the opening of the Mount Cenis Tunnel and approaches, previously described. I presume most of my audience are aware that the rails are laid on the outer edge of the highway across that part of the Alps, on a narrow gauge, having extremely sharp curves and excessively steep gradients—the curves and gradients, in fact, of a mountain road—inasmuch as the rails follow its surface. The locomotive engines obtain the necessary adhesion, and at the same time insure perfect safety to the train by the lateral pressure of horizontal wheels upon a central rail.

Owing to the limited date for its existence, which will probably be only two years longer from this time, it has been quite out of the question to construct all the necessary protective works which would have been executed for a more permanent line; then it passes over one of the Alpine summits, in a region exposed to the most violent winds (Tormentos) and drifting snow. From peculiar causes, at first perhaps unavoidable, the mechanism of the moving power was, until very lately, imperfect in design and inferior in workmanship, the result being continual repairs, with scant power, and consequently only half loads; the fact being that the old stock could hardly drag 20 tons behind it, whereas the new engines will take up 50 tons, exclusive of their own weight.

The Mount Cenis Railway between S. Michel and Susa is 50 miles in length, and has cost, exclusive of royalty and interest, during construction, about £7,070 per mile; engines and rolling stock, £862 per mile. Total, £7,932, say £8,000 per mile. Had the line been constructed on the usual gauge, and with a more solid permanent way, the cost would have been £3,000 additional, altogether £11,000 per mile. As a maximum expense, obtaining all the unfettered advantages of the system, £12,000, including stations, may be safely reckoned upon as the cost per mile of similar lines in future through a mountainous country. With gradients and curves, such as would be warranted and adopted by lines hereafter laid down on this central rail system, a comparison of distances over such a country along lines prepared for ordinary locomotive engines, to travel over gradients of 1 in 30, the steepest allowable without lateral adhesion, the time of moving, and first cost would probably be as 1 to 3; this difference of distance must also be taken into account when calculating and comparing the cost per mile of working over each system.

As regards the expense of working, the present actual cost on the Mont Cenis Railway can hardly be taken as a fair criterion. Owing to the exceptional circumstances of its construction, the narrowness of gauge and inferiority of the first engines, the working expenses have been peculiarly heavy—namely, about 5s. per train mile, viz., fuel, 1s. 6d; engine repairs, 1s. 8d.; wages, 6d.—Locomotive power, 3s. 8d.; general charges, 4d.; maintenance of permanent way, 1s. Total, 5s. per train mile. The general charges, repairs, and maintenance thus calculated per train mile would, of course, be reduced by a higher mileage, as the engine repairs are very onerous, but the new locomotives will reduce the expense of moving power fully one-third. The yearly train mileage is about 113,000, or 310 miles daily. On the ascent, the engines are perfectly steady, and equally so on the descent; in either direction, it seems next to impossible for engines or trains to get off the rails; and, in conclusion, it may be stated that up to the end of 1869 about 68,000 passengers have travelled over this line without loss of life or limb.—*Engineering.*

WIRE TRAMWAYS.—This system is by Mr. Chas. Hodgson, and may be briefly described as a continuous development of the plan often adopted in India, Australia, and America, of bridging over rivers by means of a single wire rope, on which loads are transmitted in a bucket suspended by a pulley.

The endless wire rope, now adopted, is supported on a series of pulleys, carried by substantial posts, about 70 yards apart on the average, passing round a clip-drum at the end, and worked by an ordinary movable steam-engine. Boxes, carrying from 1 to 5 cwt., are hung on the rope, in such a manner as to maintain the load in equilibrium and pass over the supporting pulleys with ease. The line is worked at a speed of about 5 or 6 miles an hour, and, the rope being endless, the full boxes travel on one side of the supports; the empties return on the other.

However rugged the country, the line can be constructed quickly, and without necessitating much more engineering work than an ordinary line of telegraph. The cost of a line calculated to transport 100 tons a day, appears to be about £400 per mile, complete for working, and the average cost of transport is about twopence per ton per mile, including maintenance. The plan has been in operation about ten months. About 35 miles of line have been made, and upwards of 100 miles are in construction.—*Engineering.*

CENTRAL PACIFIC RAILWAY.—The Central Pacific Railway Company now operate 948 miles. With the completion of the road, and its inauguration as a portion of the through line, plans for permanent improvements, relative to the perfection of the road and its equipment, were made. These consist, mainly of shops for locomotive and car building and repair at Sacramento; and their progress thus far has involved an outlay of about $1,750,000, in addition to which a million more will be requisite. These works are located at Sacramento, on a tract (filled in from 10 to 20 feet) reclaimed from the low ground of Sutter Lake and the American River. The company here own 65 acres, 23 of which have been filled, and are occupied with the shops, old and new. The shops consist of an engine house (semi-circle) accommodating 29 locomotives; a car shop, 90x230 feet, two stories high; machine shop, 100x205 feet,

eleven locomotives under repair; a blacksmith shop, 60x150 feet, having 21 forges and one blast furnace; a freight-car repair shop; together with boiler, coppersmith, tin and paint shops, oil-house, etc. The power for all these is supplied by a 150-horse power engine. The employees therein number about 900, the pay-roll of whom aggregates more than $10,000 per month. The total force employed by the company numbers about 5,000, in addition to which 2,200 are engaged in the construction of new roads.

The number of locomotives in use are 167. which are all being changed to coal-burning engines,—coal being found at Carrol Hollow, near Ellis Station, on the Western Pacific Road.

The car equipment numbers 2,086,—72 first-class passenger; 635 box; 1,293 platform; 41 emigrant; 9 mail; 16 baggage, and 20 sleeping. The freight cars were all built by the company. The equipment includes several snow plows, 11 feet high, and 10 wide. The cost of the various classes is as follows: Locomotives, $12,500; passenger cars, $7,500; box, $900; platform, $500; smoking, $6,000; sleeping, $11,500. Transportation from the East to Ogden costs—for engines, 50 cents per mile; passenger cars, $500. Cars are not only built, but repaired at Sacramento—it being more economical to haul cars even from Ogden, than to repair them at division stations.

The following table presents valuable statistics of operation on the Central and Western Pacific Roads.

Central Pacific.

Miles run	212,106
Pints of oil	18,349
Cords of wood	6,152
Cost of repairs per mile	8.87 cts.
Cost of engine men per mile	6.89 cts.
Cost of stores per mile	1.59 cts.
Cost of wood per mile	20.09 cts.
Miles run to pint of oil	11.56
Miles run to cord of wood	34.47
Total cost per mile	37.44 cts.

Western Pacific.

Miles run	74,535
Pints of oil	6,889
Cords of wood	2,051
Cost of repairs per mile	12.51 cts.
Cost of engine men per mile	7.16 cts.
Cost of stores per mile	1.88 cts.
Cost of wood per mile	16.51 cts.
Miles run to pint of oil	10.82
Miles run to cord of wood	36.34
Total cost per mile	38.06 cts.

For purposes of supervision to secure safety of trains, the line is divided into six-mile sections, and every mile is daily partrolled,—the section-men, provided with signals and simple tools, thoroughly examining curves, bridges, culverts, switches, and rails.—*Chicago Railway Review.*

Railway Construction in this Country.—The official figures showing the number of miles of railway constructed in the United States in 1869 have not yet been published, but the actual increase is believed to be 7,745 miles, which is far greater than the aggregate of any former year.

The largest amount in any previous year was in 1856, when 3,643 miles of road were built, while in 1868 only 2,978 miles of new rails were laid. Since 1826, when Massachusetts began to lay iron tracks, the construction of railroads in this country has averaged more than 1,000 miles a year, and in the last five years the average has been more than 3,000 miles a year.

Counting the cost of construction at $40,000 a mile, we expended during the last year $300,000,000 in building railways, with probably $300,000,000 for expenditures beyond building. The present distribution of railway lines is nearly as follows: 4,000 miles in New England; 17,000 miles in the Western States; 900 in the Pacific States; 10,000 in the Middle States; 11,000 in the Southern States. The war scarcely checked railway building in the North and West; but it ruined the Southern roads, most of which have since been relaid and supplied with rolling stock, or are now in process of relaying and supply.

And new roads are now building, or are projected, in every part of the country. Texas is pushing through a central road, which may become the southern route to the Pacific Coast. Illinois is building a dozen different roads, which will cover 500 miles. Michigan is engaged upon three new roads, covering 100 miles. Six new roads, extending over 300 miles, are in progress in Iowa. Missouri is pushing on her South Pacific. Oregon, California, Kansas and Nevada are all building new railways. And last, but not least, Virginia projects a great central road through the State, which will make, with connections, direct transit from Norfolk on the coast to San Francisco. These are the leading railway enterprises, and to these should be added the efforts New York and Baltimore are making to perfect their railroad connections with the West.—*N. Y. Evening Post.*

Intercommunication in Canada.—Notice is given in the offical "Gazette" of Canada that an application will be made to Parliament next Session for an Act of Incorporation for a company to build a railway from Ottawa to Fort Garry, Red River, and thence to the confines of British Columbia; also for the construction of a branch from Fort Garry to the most convenient point in the United States, with power also to build steamers and other vessels to navigate the River Saskatchewan and its branches, and the rivers and lakes traversed by the railway; also that the money credit of the Dominion be extended in aid of such company by granting mortgages on the wild lands of the Crown along the route in proportion as the work proceeds. The name of the company will be "The Canadian Pacific Railway and Navigation Company."—*Engineering.*

Penobscot Bay Railroad. — Capt. Buckland, C. E., has completed the surveys and estimates for the Penobscot Bay and River Railroad from Rockland to Winterport, Maine, a distance of 50 miles.—Total cost of road ready for the rolling stock estimated $1,332,819; average cost per mile ready for rolling stock, including stations, buildings, engine-houses, etc., $26,656.38.

A Railway in Japan.—The project for a railway to Yeddo (Japan) is said to have been revived, and the Japanese Government are in a treaty with a Belgian firm for the supply of the necessary plans.

Russian Railways.—It is announced that the Russian Government has just decreed a considerable extension of the railway system in the

Caucasus and elsewhere, in order to open up the country and promote trade.—*Engineering.*

RUNNING STREET CARS WITH TANKS OF COMPRESSED AIR.—A company organized in New Orleans to utilize several inventions which Mr. Whaley has devised for the application of condensed air as a motive power for cars on city railroads, is soon about to bring the design to a test.

In company with parties interested in the improvement, we visited the foundry of Captain F. Roberts, at the corner of Julia street and the levee, where the apparatus is being constructed. Captain Roberts explained the plan of the apparatus.

The idea is that each car shall have 2 cylinders, or tanks, to contain the compressed air, which is to be used as a motor. These cylinders are to be on the top of the cars, and are to be charged at the depot by an engine worked with steam. Metallic cylinders were first tried, but they were found to be too heavy, and the difficulty of the company has been to find a lighter material available for the purpose. Paper cylinders have been determined on, and Captain Roberts is engaged in making four to be used on the cars, two on each. They are made of strong sheets of paper, laminated to a thickness sufficient to bear the great pressure required to contain the air condensed into steam. The several lamina are adhered with glue, and the paper fabric is strengthened with an envelope of cordage. In connection with these cylinders there is to be an engine, for which a special patent has been taken out, and which is otherwise valuable in its applicability to steam machinery, to receive the condensed air and rotate the wheels of the car.

One of the cylinders was finished. It has been subjected to a trial of 300 lbs. to the sq. in. and had not yielded. Three hundred lbs. to the sq. in., he observed, would suffice as a motor. He had, with a platform car, experimented on a street railroad with far less power than that, and the experiment resulted satisfactorily. He used two old iron cylinders, weighing 1,600 lbs., which leaked through the riveting, and there were 28 persons on the car.

Starting with but 90 lbs. of pressure to the sq. in., and with the weight of cylinders and men mentioned, he made 3½ miles in 7 minutes and 15 seconds. And as to curves, when the motor was reduced to 15 lbs., to use Captain Roberts' own words, he went around a street corner, "as smoothly as a ball would roll on a billiard table."—*New Orleans Republican.*

FRENCH REPORT ON THE EMPLOYMENT OF MINERAL OILS FOR THE HEATING OF LOCOMOTIVES.—MM. Sainte-Claire Deville and C. Dieudonné, on the result of experiments made at the instance of the Eastern Railway Company of France, have drawn up the following report on the above important subject:—"Under present circumstances we are of opinion that in consequence of the enormous production of steam in locomotive boilers well-constructed and heated by means of mineral oils, until, by well-conducted and very deep soundings, petroleum, which there is every reason to believe exists in certain well-known spots in France, shall have been brought to the surface, and until all the products of the distillation of coal and schist can be condensed, coal oils may be employed with advantage for the heating of the boilers of locomotives employed to draw heavy trains at high speeds. The following are the results produced by a rather powerful engine, and attached to the report:—The locomotive was of the mixed kind, four wheels coupled, diameter of cylinders 0.42m. (18 ins.), total heating surface 100 square metres, adherent weight 19½ tons. It has to the present time run over nearly 900 miles of line, and the consumption of oil has been at the rate of 5 kilogrammes per kilometre (19 lbs. per mile) when running; to which has to be added 216 lbs. for getting up steam and 60 lbs. per hour when standing with fire alight. The weight of water vaporized was in the proportion of 10.90 kilos. per one kilo. of oil; good briquettes convert only 7.90 kilos. per kilogramme of fuel. The proportion of the two, then, is 138 to 100. The furnace remains in good condition and promises long service, and it may be stated that if heavy oils can be obtained at fair prices, the engine will do good practical work."

A SCHEME for a Canadian Pacific Railway appears in the newspapers of the Dominion. The length of the line is 2,500 miles, and the capital £20,000,000.

ORDNANCE AND NAVAL NOTES.

THE AUSTRIAN TORPEDO.—The most recent addition to the history of the Torpedo question and its practical development, is furnished by some experiments which have lately been carried out in Austria with a submarine self-propelling torpedo. Our pages bear ample testimony to the ingenuity which has been for several years past expended upon instruments of the torpedo class for defence against the attack of war vessels. During the Russian war, Cronstadt was defended by this class of weapon, sunk in the channels of approach and ready to be fired by electricity. Later on, during the American war, similar means were resorted to for coast and harbor defence. In the present instance we have a powerful agent of destruction, which may be seen at the little port of Fiume, in the Adriatic. We are not able to place a detailed description of this machine before our readers, inasmuch as the important parts are kept secret by the inventor, who prefers to do this rather than to patent his principle, and thereby expose its peculiarity. We can, however, furnish a general idea of its external form and what it is capable of doing, having been favored with these particulars by a correspondent—Mr. Andrew Leighton, of Liverpool—who has recently returned from Fiume, where he witnessed the experiments with the torpedo. In appearance this formidable weapon is like a fish, approximating to the form of the sword-fish. But, besides a projecting snout, it possesses a vertical and two lateral projections, all of which are triggers, and any one of which impinging upon an object with sufficient force explodes the machine. It has, therefore, when in operation, four chances of effecting its purpose—by the direct stroke in front, or the oblique from either side, or the hit above in passing under the bottom of any object against which it may be launched. It can be charged with any explosive material—gunpowder, gun-cotton, dynamite, or nitro-glycerine—and the explosion can be of such force as to drive a hole into the strongest iron-clad sufficient to sink her at once.

The most prominent and important feature in

the invention is the means by which it can be propelled at any required depth below the surface of the water. When the depth at which it is to proceed is fixed upon, it can be driven in a horizontal plane at that depth, towards any mark, at a maximum speed of ten knots an hour. While Mr. Leighton was at Fiume, a commission from the United States, consisting of Admiral Radford and two officers of the United States frigate "Franklin," was engaged in investigating its nature and powers. The experiments had just closed when Mr. Leighton reached the scene, but the inventor subsequently showed the torpedo in operation. It was set off from the side of a boat, and after attaining a depth of some six or eight feet from the surface, it kept, as nearly as could be judged, the same level, and made three circuits, of from 100 to 150 yards each, round the boat, coming to the surface when its propelling power—compressed air—was exhausted. The water at Fiume is very deep and remarkably clear, so that the monster fish was perfectly defined at the depth stated. Its course could also be seen by the bubbles of air coming to the surface in its wake at a considerable distance behind it. The invention of this torpedo is due to Mr. Robert Whitehead, an English engineer resident at Fiume, and chief of an engineering establishment there. The idea was first started by Captain Luppis, a retired officer of the Austrian navy, who suggested to Mr. Whitehead the desirability of a floating and running torpedo, the forepart to be filled with explosive material and the after-part with the motive power, which latter was to be steam. But, on giving his attention to it, Mr. Whitehead soon saw that Captain Luppis's notions were wholly impracticable; that a surface-floating body would never answer the purpose; and that fire or steam in close proximity to explosive material would be so dangerous that this idea of the gallant captain had to be abandoned as worse than useless. He, therefore, set to work upon an idea altogether his own, which was to form a fish instead of a steamboat; and, after innumerable mistakes, failures, and disappointments, his perseverance was at length rewarded by the triumphant success already indicated. Thus to English, and not to Austrian, mechanical genius—as has been incorrectly stated in some quarters—belong the honors of this latest achievement in the art of defensive warfare, which, if it does not render other coast defences needless, must at least be acknowledged as a potent auxiliary for maintaining our island home invulnerable; that is, if our Government have had the wisdom to possess themselves of its secret. It is impossible for any one who has seen this torpedo in operation to hesitate in his judgment as to its superiority over anything of the kind hitherto invented; and it is difficult to estimate the extent to which this single invention will modify the arts of attack and defence by sea.—*The Mechanics' Magazine.*

THE GRAHAM STUART BREECH-LOADER.—At the meeting of the United Service Institution, held on Monday the 17th inst., Captain Selwyn, R. N., in the chair, a paper was read by Captain Graham Stuart, 4th York Volunteer Artillery, on his "Patented System of Breech-loading Cannon." Captain Stuart reviewed the existing systems of breech-loading cannon. The three essentials may be stated as gas-tightness, strength, and simplicity of construction.

Sir W. Armstrong's system supplied the two first, but its complicated construction made it unsuitable for heavy artillery. Mr. Krupp's gun is elaborate, and essentially weak. The Parsons gun, an application of the system by which a sphere, made to rotate a quarter of a circle, is placed in the breech and perforated according to the bore, gives strength and simplicity, but it has hitherto been impossible to prevent escape of gas. Four years ago Captain Stuart turned his attention to the subject and produced an arrangement approved of by the highest authorities. He has since added improvements, and now brings forward his system as combining these three essential requisites.

An ordinary gun forging, somewhat enlarged in the internal diameter of the breech, is bored as usual, but the part of the boring in the breech is made two or three times as large as the remainder. Into this a sphere of metal, perforated as the bore, is introduced. One face of this has a *spiral* perpendicular projection. This fits against a bronze expansion ring fitted into the rear end of the bore, and acts as a wedge, completely sealing the breech. This sphere is mounted on gudgeons, which pass through the sides of the breech, and is turned by handles outside the gun. It rotates on its axis a quarter of a circle to open or close the breech. The perforation being accordingly in a line with, or at right angles to, the bore, the sphere rests against a heavy perforated breech plug screwed into the solid breech. Through this the charge is introduced; the operation of opening and closing is easy and expeditious; so much so that whereas an Armstrong gun requires ten men to work it, this gun can be worked with eight. The openings in the breech being the smallest possible consistent with breech-loading, strength is secured. The simplicity is evident from the fact that there are only three principal parts of the breech concerned in resisting explosion and force—viz., the plug, ball, and expansion ring. The prevention of gas escape is completely obtained. In the course of repeated trials this has been carefully tested, but none has been observed. Other advantages are the absence of openings into the sides and top of the breech, and the rapidity of fire attainable. The inventor has fired 6 rounds in 35 seconds, equal to 10 rounds per minute. The gun will stand hard work and rough usage. It was left without cleaning for several days, and at the end of the time the breech was opened without difficulty.

A gun made on this principle which has been fired more than 100 times, is deposited in the museum of the institution, and the courtesy of the governing body allows any of Captain Stuart's friends to inspect it. The Ordnance Committee recommended this gun, and Captain Stuart was desired to prepare working drawings for a 300-pounder, to be constructed at Woolwich. He sent in the drawings accordingly, but the War Office finally declined to incur the expense.

In answer to questions, Captain Stuart stated that the principle of the spiral projection prevented any jamming or fracture arising from unequal expansion of the sphere and the side of the breech. He had adopted a groove or "gutter" on the roof of the breech chamber in his working drawing as an improvement on the construction of the gun in the museum, the screw plug of which ten threads bite had never given way, though the gun had been fired with overcharges.—*Engineering.*

THE MONCRIEFF GUN CARRIAGE.—The first of the wrought iron carriages and platforms for 12-ton rifle muzzle-loading guns, manufactured in the Royal Carriage Department, Royal Arsenal, Woolwich, under the superintendence of Col. H. Clerk, Royal Artillery, from designs furnished by Capt. Moncrieff, of the Edinburgh Militia Artillery, was submitted, last Monday afternoon, to a private trial at the proof butts in the Government marshes at Plumstead, for the purpose of ascertaining the amount of counterweight required. Three rounds were fired, without any alteration being required, with projectiles of 250 lbs. weight, and increasing charges of 30 lbs., 35 lbs., and 40 lbs. of powder, the carriage working with the most perfect ease and regularity. At the last round fired a fracture was observed in the axle, near the right cheek of the carriage. The trial, as far as the general principles of the carriage are concerned, was highly satisfactory. The total weight of the platform, elevator, carriage and gun amounted to nearly 50 tons.

RUSSIAN NAVAL ARMAMENTS.—The "Cronstad Messenger" says that all the ironclads in the Russian fleet are now provided with new 8 in. and 9 in. steel guns. Some monitors have been armed with 15 in. smooth bores, and all vessels intended for long journeys have 6 in. rifled steel guns. A huge smooth bore gun of 20 in. calibre has been constructed at Perm. All these guns were made in Russia. Every man in the navy, too, is now armed with the new rifle, according to the Baranoff system.

THE MARTINI-HENRY RIFLES.—Several of the Martini-Henry rifles were forwarded, some time since, to the southwest military district, and are now being subjected to a series of practical tests over the army rifle ranges on Browndown, near Gosport. So far, the opinion appears to be that the new weapon is very superior to the Snider, but that many of the details connected both with the weapon itself and its equipment are open to considerable improvement. The ammunition pouch, carried in front, is decidedly faulty in its arrangement.—*Engineering.*

THE 600-POUNDER GUN AT SHOEBURYNESS.—The 12-inch 600-pounder rifled muzzle-loading gun of 25 tons, at Shoeburyness, now being tested as to its power of endurance, is about to be subjected to the ordeal of the second hundred rounds of the 500 hundred rounds ordered to be fired with 67 lb. charges of rifle large-grain powder and Palliser shot and shell of 600 lbs. weight. The mean range of this powerful gun, at 10 degrees of elevation, is found to be about 4,000 yards.

MANUFACTURE OF GUNPOWDER.—It is stated by many writers that no gunpowder was manutured in England until the reign of Elizabeth. But Sharon Turner has shown, from an order of Richard III., in the Harleian manuscripts, that it was made in England in 1483; and Mr. Eccleston, in his "English Antiquities," states that the English both made and exported it as early as 1411. At all events, it long remained a costly article; and even in the reign of Charles I., many complaints were made of its dearness, "whereby the train bands are much discouraged in their exercising."

ENGINEERING STRUCTURES.

EXTRAORDINARY SCENE ON THE HUMBER.—Last week we recorded the failure of the first attempt to raise the sunken pontoon at New Holland. After the system then adopted failed, Captain Hollingsworth, one of the masters of the company's steamers, was allowed to try a system of his own, and he set to work on the following morning. Ten ballast lighters from Hull were obtained, each of a carrying capacity of about 60 tons, and 9 of the company's goods lighters, with a capacity of about 70 tons. All these lighters were strengthened and fortified with massive woodwork, and across each were placed two very strong beams—one across the bow and one across the stern; but none of the beams projected over the sides of the lighters. Thus each of the 19 lighters had attached to it 4 chains, which had previously been fastened to the beams of the pontoon. The whole of the lighters were got over the pontoon between 11 and 12 o'clock on Saturday, and there was only about 1½ hours in which to fasten all down before the flood tide set in. The work was, however, accomplished. About 4 o'clock the strain began to be felt by the lighters, and anxiously were they watched by Mr. Sacre, the company's engineer, Captain Hollingsworth, and Mr. Barber, the superintendent of the locomotive department. By half-past four most of the lighters were pretty well down in the water, and in a few minutes more it was seen that the whole mass moved upward with the rising tide. Half-an-hour more passed away, and still the lighters continued to float, and there was not the slightest sign of any thing giving way. Meantime the tide increased in strength, and it began to bubble and foam amongst the lighters in a manner which showed what a fearful strain was put upon the vessels. Exactly at 5 o'clock the action of the tide forced the pontoon out from the dolphins which for the last twenty years have kept it in position. The eastern end was the first to move, and as the vessels were seen to swing out into the open river the large number of spectators gave three hearty cheers. Soon the whole were floating well out; but the tide, which was flowing with unusual force, caught the east end of the pontoon, and swung it athwart the stream with such violence that the lighter at that end was almost submerged. The two men stationed on board were afraid that the vessel was about to sink, and they at once cut the lashings which held the chains together. The effect was to throw a sudden strain on the next lighter, which was also liberated, and the next, and the next. Cutting adrift then became general, and such a scene ensued as is rarely witnessed. The men on board the lighters appeared to become nervous. The man at the head would cut his chain adrift before the man at the stern could do so, and the result was, that the end or the vessel first liberated flew high in the air, the lighters for an instant standing almost perpendicular. On board one lighter the chains appeared to have been liberated exactly at the same moment, and many of the spectators declared that the vessel jumped clean out of the water. The men with their hatchets made fire fly in all directions, and altogether the scene for about three minutes was one that will not easily be forgotten by those who witnessed it. Before the last lighter had been cut adrift, the pontoon was once more at the bottom; but it is now out of the way of the passenger traffic, which

has been most seriously interfered with since the accident.—*Railway News.*

VANDENVINNE'S STEAM EXCAVATOR.—Upon a plot of waste ground on the north side of Victoria street, Westminster, and about half-way down, may be seen at work at the present moment a steam excavator of novel construction. There it is, pegging into a mound of rubbish, composed of earth, brickbats, and fragments of slate and paving-stones, the whole well consolidated by time and —when we visited the spot—case hardened some 2 in. deep by the frost. The apparatus is the invention of M. Vandenvinne, of Belgium, who has had a machine at work in that country with satisfactory results. The present excavator is to be considered only as a model, although one which practically illustrates the principle of the invention. It is self-contained, and consists of a boiler and steam-engine, which gives motion to the excavating apparatus. This consists of a pair of vertical shafts, placed in front of the machine, and around which are keyed a series of horizontal picks, placed radially so as to command a circle. Both the shafts have an inward motion, and the picks are so arranged as to pass between each other's spaces. As the picks bring the soil down, it is carried by them into a set of buckets on an endless band, set at an angle, and running over pulleys in the rear of the picks. The buckets deliver the soil on to an endless horizontal platform placed over the back of the machine, and this in its turn conveys the soil down a shoot, depositing it in the rear of the apparatus. The shoots, however, can be arranged so as to form a spoil bank on each side of the machine, if necessary, instead of making one in its wake.

The forward motion is effected by means of another endless platform carried over a set of rollers in the lower part of the machine. When out of work this platform can be raised, and the machine is then carried on a set of wheels by which its transit from one point to another is effected. The excavator can be set to work either at an upward or a downward angle of inclination, as well as at a dead level. Although this is only to be considered as a model machine, it is not so small as might be imagined; it measures 12 ft. in length, excavates a width of 5 ft., to a depth of 3 ft., and weighs about 4 tons.

The Belgian machine to which we have referred was of larger dimensions, being 25 ft. long, cutting to a width of 10 ft, and weighing about 15 tons. Upon our recent visit to Victoria street, we found the machine at work on the mound of rubbish we have mentioned, regularly advancing at a rate of travel of about 3 in. per minute. There were occasional interruptions, owing to the presence of large blocks of paving stone, which naturally jammed the picks; but with these exceptions the machine worked steadily on, brickbats and slates being readily disposed of by the picks and buckets. This steam excavator is being introduced into England by Mr. C. F. T. Young, of the Adelphi, who is preparing working drawings of the machine, which, with a detailed description, we shall shortly place before our readers.—*Engineering.*

THE NEW TUNNEL IN CHICAGO.—A second tunnel is to be built under the Chicago River at Chicago, for the purpose of connecting the two divisions of the city. The work has already begun. The Chicago *Tribune* gives a detailed description of the proposed tunnel, from which we take the following facts and figures:

"The tunnel is to be placed with its centre line in the centre of La Salle street. The southern approach is to begin 40 feet north of the north line of Randolph street, and the north approach to terminate at the south line of Michigan street. The bottom of the tunnel, or top of invert, in the centre of the river is to be 35 feet below low water. The grades between the ends of the approaches and the centre of the river to be uniform, except on the river portion of the work, where it will be less than on the approaches. The tunnel under the river is to consist of three passageways. The east one for foot passengers, and the other two for horses and vehicles drawn by horses. The east passageway is to be 12 feet high between the bottom of the upper arch and the top of the invert. The width of this passageway is to be 10 feet. The other passageways are to be 11 feet wide, their inverts to be segments, the upper arches to be from three centres; a flagging course of 10 inches thick is to be laid entirely across from one side to the other of the tunnel. The section of the tunnel above described is to extend entirely across the river, a distance of 300 feet. The flagging course over the top of the tunnel will extend for a distance of 280 feet only, including two and a half feet to be built under each dock wall. Beginning at a point 150 feet each way from the centre line of the river, the section of the tunnel changes to a single opening or passageway, beginning here with a width of 24 feet 4 inches, and diminishing to a width of 19 feet 6 inches, in a distance of 40 feet, or to points 190 feet on each side from the centre line of the river. At the point 150 feet each way from the centre line of the river, the centre of the single passageway begins with a height between the top of the invert and the bottom of the top arch of 21 feet.

"The opening approaches to the tunnel on each side, and the passageway for horses, are to be paved with wooden block pavement (the whole distance being 1,890 lineal feet), resting on lake shore sand, in the manner shown on plans, and according to the usual specifications of the Board of Public Works for such pavements.

"The contract requires that the river shall be entirely free and unobstructed, as also North and South Water streets, by the 1st day of April, 1871, and the tunnel to be completed and ready for public use by the 1st day of July, 1871. This is about the same length of time employed in the construction of the Washington street tunnel. The total cost of the La Salle street tunnel is expected to be upwards of $475,000."

THE FOOT BRIDGE AT PRAGUE.—Our readers will doubtless remember that in June, last year, a new bridge was completed and opened at Prague. This bridge—the Franz Joseph—was designed and constructed by Mr. R. M. Ordish, of Westminster, upon his rigid suspension principle, which has been described in our columns. The success of this principle led to the construction of another bridge upon the same system and across the same river—the Moldan. This second bridge is for foot passengers only, and has the peculiarity of having one central tower and two abutment piers, thus forming two half spans. This special feature was necessary, in consequence of the character of the river bed and other local considerations. This bridge has a platform width of 11 ft., and each span is 305 ft. 6 in. in the clear. The works of the

bridge having been completed, it was tested on the 22d and 23d of last month by a commission appointed by the municipality, under the superintendence of the resident engineer, Mr. Max am Ende. The test load consisted of 42,500 bricks, equivalent to a load of 457,640lbs., equal to a distributed load of about 64lbs. per square foot. This load remained upon the platform for one hour. During that time observations were made at each span; the maximum deflection was 6¼ in. and 6¾ in. respectively; the anchorage chains extended over $\frac{1}{12}$th and $\frac{1}{8}$th of an inch. The estimated deflection was 7½ in. On the 24th the bridge was cleared of its load, when the permanent set was found to be half an inch, the anchorage chains having returned within $\frac{1}{24}$th of an inch to their original position. The bridge is found to be exceedingly steady under uneven loading, and it has been exposed to heavy gales with like results.—*Mechanics' Magazine.*

Powerful Turbines.—A correspondent of the "American Odd Fellow" thus describes the turbines used in the Mastodon Mill, in the village of Cohoes, New York: "The entire number of looms in this mill is fourteen hundred and eighty-six; five hundred of which are located on the first floor.

"These looms and the other machinery of the mill are driven by three immense turbine water wheels, made by the Ames Manufacturing Company, which operate the main shaft, and possess an aggregate driving capacity of over 1,100-horse-power. This pit having an extreme depth of 40 ft., with a floor 25 ft. from the surface, which hides the water wheels from a top view, is, in reality, an underground two story building. Three mammoth cast iron cylinders, 8 ft. each in diameter, convey the water from the canal on the west side of the building to the wheels; the volume of water being regulated by a sort of tiller located in the pit, and connected with flood-gates. The perpendicular shaft of each turbine is connected with the main shaft by bevelled gear, and the united power exerted, if so applied, would reverse the motion of the great Burden water wheel at Troy, and drive the machinery of a good-sized manufactory besides. The shaft to which this wondrous power is applied is supported by three granite abutments, and forms the axis of six ponderous driving pulleys, 12 ft. each in diameter. The immense belts which radiate to all parts of the building are in keeping with the massive pulleys and gearing. These are each two feet wide, and the longest one reaching to the fifth story, measures nearly 200 ft. At the north end of the pit, two rotary force pumps are located, which, in case of fire, can be instantly geared to the main shaft by means of a sliding cog-wheel, and are jointly capable of throwing six thousand gallons of water per hour.

Mont Cenis Tunnel.—The long tunnel popularly known as that of Mont Cenis, really passes below a different mountain. It connects the railways of Italy, converging at the town of Susa, at the foot of the eastern slope of the Alps, with the railways of France, at present terminating at the village of St. Maurice, in Savoy, west of the range. The mode of driving this tunnel has been before described; at present I have simply to note its progress. The total length of actual tunnel is 12,220 metres, say 7⅔ English miles; the aggregate length of the driftways, completed from each end, is 10,598 metres, or 6⅔ miles; so that there is only one mile of driftway to finish; the rate of progress being from 3¼ to 4 yards a day, the piercings from end to end may be expected early in the spring of 1871. The enlargement to full size and the lining of the tunnel, is always kept up to about 300 yards behind the headings in each direction. Assuming that the tunnel, with the deep cutting approaches at each end, will be finished in the course of the year 1871, it will have occupied thirteen years in construction, at a cost not less than four millions sterling.—*Engineering.*

A Big Canal Scheme.—The California Commissioners on Swamp and Land Reclamation have reported favorably upon a project for an extensive canal through a portion of the Sacramento valley. This report, with the estimates to follow it, will be made the base of a bill providing for the issue of $4,000,000 of State bonds, to be paid by a tax levied on the reclaimed lands. Such a project, says the "San Francisco Bulletin," is of doubtful constitutionality, even if it were politic, which it is not, to loan the State credit for so large a sum, or for any sum whatever, in behalf of a local and private improvement.

The Induration Process.—Mr. Ransome's method of water-proofing walls by means of successive solutions of silicate of soda and chloride of calcium, which has been applied with so much success to many public and private buildings in England, is being used extensively in India to arrest the decay of many brick structures upon railways in that country. Amongst others we may note the Waree Bunder Works, upon the great Indian Peninsula Railway, which were constructed of such inferior material that a rapid deterioration speedily followed the construction of the works, and the crumbling of the bricks left no alternative apparent save that of rebuilding. It was, however, determined to experiment with Mr. Ransome's process, and, accordingly, in 1868, it was extensively applied to the failing buildings, with the result of effectually stopping the decay, and of placing so fine and hard a surface upon the bricks that the material, which before could be crumbled by the touch, received a surface so hard as to resist the scratching from a steel point. In this manner extensive workshops and a chimney shaft were, at an insignificant outlay, rescued from destruction and rendered sound and durable.—*Engineering.*

NEW BOOKS.

The Metallurgy of Iron and Steel, Theoretical and Practical: in all its Branches, with Special Reference to American Materials and Processes. By H. S. Osborn, LL.D., Professor of Mining and Metallurgy in Lafayette College, Easton, Pennsylvania. Philadelphia: H. C. Baird. 1869.

The metallurgy of iron has lately had very much thought expended upon it, yet the subject is by no means exhausted, and the number of results scientifically determined and systematically arranged is so small that metallurgists, professional or practical, all welcome very eagerly any additions to our stock of knowledge. We hoped when we saw this ponderous volume of nearly one

thousand pages, by Professor Osborn, not only to find much that should be new and valuable, but a work that should correctly represent the state of the American iron industry. The least that could be expected of such a work was that it should be a careful and accurate résumé of the most important facts relating to the subject, and that it should be written in an intelligible style. In perusing the book we were sorry to find all our hopes and expectations speedily and entirely disappointed.

From the preface we learn that Professor Osborn first intended simply to re-edit Mr. Overman's treatise on iron, but finding it impossible, on a "thorough examination," to make it represent correctly the present stand-point of iron metallurgy, he therefore wrote "a work almost entirely different in method and in matter." "There was, nevertheless, so much material in Mr. Overman's book which was useful," we read in the preface, "that it has been introduced and acknowledged, either by the use of his name or by enclosing the quoted matter in brackets." The "so much material" referred to comprises over three-fourths of Overman's work, making fully one-half of Osborn's, with Overman's original illustrations, as published in 1850, and we were surprised to find the numerous and well-known inaccuracies and blunders of Overman retained in full.

For instance: In the original work appeared an impossible analysis of peat ashes, which was, perhaps, a misprint. But Dr. Osborn seems to have such implicit confidence in Overman as to deem it unnecessary to question any of his statements, so here (page 184) we have perpetuated an analysis of peat ashes of unheard-of composition, containing no less than 133⅓ per cent. of oddly combined ingredients. An error once started is hard to stop, and this absurd statement once more revived is destined, doubtless, to meet us often. It has already found its way into the columns of a prominent technical journal, the "Engineering and Mining Journal," where the article on peat was given in full with editorial approval.

Welter's law, that "the amount of heat liberated by the chemical combination of various substances with oxygen is directly proportional to the amount of oxygen consumed," long since proved to be inaccurate, is retained by Osborn as "one of the most useful inculcations of chemistry" (page 245).

Overman's work contains, it is true, many useful practical details of the manufacture of iron, but is wofully deficient and inaccurate in the scientific treatment of the subject. The fact that any one should endeavor to build up a work on such a foundation does not promise well for the superstructure.

The first chapter in the book, on the general principles of the chemistry of iron, is, doubtless, original with Professor Osborn, at least it has never been our lot to meet with anything so remarkable in chemical or metallurgical literature elsewhere. It is, perhaps, the most incoherent, obscure, incorrect, and puerile chemical production that has been written since the days of the alchemists. With the intention of making himself intelligible to the most ignorant of his readers, he playfully calls carbonic acid the *rust of carbon*, analogous to the rust of iron. He states incidentally that heat will expel oxygen completely from oxide of iron—a statement so manifestly false as to need no refutation. On combustion his ideas are ludicrously vague. It is clear to him that carbonic oxide, being the product of the partial oxidation of carbon, is a combustible gas; not, however, because it is capable of combining with more oxygen, but because "carbon is consumable, and oxygen, as we have said, supports combustion; all the conditions therefore of flame or fire exist in carbonic oxide." Carbonic acid, being the product of the complete oxidation of carbon, will not burn. The Professor, duly recognizing the fact, is puzzled to know the reason why; for, according to his theory, it ought to be more combustible than carbonic oxide. It remains, notwithstanding, obstinate in its combustibility, and he is forced to content himself with calling the fact "an anomaly." We can imagine, when the Professor contemplates the combustibility of hydrogen, how surprised he must be that water does not burn! He should peruse as soon as he can some elementary work on combustion, and meantime rest satisfied with the reflection that what has been already completely burnt cannot be burnt again.

The looseness of style in which the book is written is apparent on every page. For instance, on page 25 we read: "It (phosphoric acid) combines with the iron, to the great vexation of the iron manufacturer." Phosphorous, not phosphoric, acid, is meant.

On page 24: "The oxide of silicon is silica or quartz"—which is inaccurate; what is meant is, that silica is *an* oxide of silicon—"and silica is the substance silicon combined with oxygen, making silica."

The following sentence, on page 158, may be said to be well mixed: "The properly sized crucible having been taken, line the interior with charcoal powdered and mixed with water, or water and molasses, or molasses alone, previously well mixed with the coal and the latter thoroughly triturated into the mass in the mortar." Mr. Dixon, the well-known crucible maker of Jersey City, will, perhaps, be surprised to find himself quoted as saying (p. 540), "that the nearer a crucible comes to being all plumbago, the quicker it will melt."

The particulars of original experiments are fortunately very rare in the book, as Dr. Osborn seems to be incapable of judging correctly of the results he obtains. From three experiments, tried on silicious, argillaceous, and calcareous ores, he concludes that any of these ores, on being strongly heated in a crucible with a well-fitting cover, without the addition of carbon or any reducing agent, will become partially reduced to metallic iron, the amount of the reduction being in proportion to the amount of lime present. We do not give his conclusions in his own words—they are too obscure; but we have, we believe, correctly interpreted his meaning. Dr. Osborn must not expect to overthrow so easily the accumulated evidence of generations, that oxide of iron, whether in the presence of silica, clay, or lime, cannot be decomposed by heat alone.

The directions given for the analyses of ores, fuels, and fluxes, are entirely superfluous. For one acquainted with chemical methods they are crude and inaccurate, and to one not familiar with chemical manipulation they must be utterly inexplicable. The Professor's own ideas of chemical analysis are evidently very vague. He divides the "wet assay," for instance, into, first, volumetric assay; second, chemical analysis. It will, doubtless, be new to many that volumetric is to be distinguished from chemical analysis.

The confusion and misuse of scientific terms is a peculiar feature of the work. On page 316, we are informed that the furnace is divided into four zones of *specific heat*, meaning specific action, for which blunder Percy is made responsible on page 326. On page 185 we read: "The specific gravity of a cord of wood is from two to three thousand pounds." This is retained from Overman. On page 27, manganic acid is called manganese acid. For pure oxide of iron (page 143) we read oxide of *pure malleable iron*. *Determination* of substances is used for *detection* (page 117). On page 169 we hear of a protosalt being *reduced* to a sesquisalt. On pages 132 and 913, *chromic iron ore* is called *chromate of iron*.

Scientific nomenclature has been enriched by the Professor with some original terms, such as, *oxygenated* and *carby-oxygenated crude iron!* (pp. 140, 141). *Quality of heat* is said to mean *temperature* (p. 243).

In the preface, Dr. Osborn acknowledges that in the chapter on the special properties of iron and its compounds he has been greatly indebted to Percy's work. Any one familiar with the able treatment of this subject by Percy will be incensed by the way his statements and experiments have been misquoted. It looks as if Dr. Osborn had turned over the leaves of Percy's book and taken sentences at random, without regard to their connection or relative importance, always altering the language to the detriment of the idea. We give a few quotations by way of illustration: We read in Percy's work ("Metallurgy of Iron and Steel." London. 1864), page 79: "By washing the residue the arsenic is separated as soluble alkaline arseniate, while pure sesquioxide of iron is left." Osborn (page 107): "On washing the residue, pure alkaline arsenic is removed and pure sesquioxide of iron remains." Percy (pp. 98–100) gives the details of six experiments on the reduction in silicate of the protoxide of iron by carbon, from which is proved that "only two equivalents of the protoxide of iron in tribasic silicate can be reduced by carbon." Osborn (page 111) did not see the drift of the experiments and overlooked the result, and has given merely a condensed account of the first experiment with this result: "Product: well-melted buttons of white iron." At the conclusion of an interesting series of experiments by Percy on the carburization of malleable iron by means of hydrogen which has passed over charcoal at a red heat, he says: "The questions suggested by this point are, Did hydrogen under these conditions take up any carbon, or was the gaseous compound of carbon which caused the carburization of the iron simply evolved from the charcoal employed?" "The question arises," according to Osborn, "Was it from the hydrogen mechanically taking up carbon, or was it from hydrogen eliminating, by some chemical affinity, the, so to speak, latent carbon of the charcoal, and thus charged with carbon, passing over to the piece and carburizing it?" Such a jumble of words may convey an idea to Dr. Osborn, but will not edify many of his readers.

In the chapter on iron ores, Dana is also misquoted. We read (p 43): "Dana includes all these varieties" (bog-iron ore, etc.) "under the specific name of Limonite." In Dana's "System of Mineralogy," 1869, page 172, we read under Limonite: "Only *part* of stalactitic limonite, brown or yellow ochre, bog ore, and clay ironstone belong here."

Instances might be multiplied indefinitely of this system of garbling extracts without regard to the author's meaning, but we forbear. We must not forget to mention that the element fluorine, which has up to the present time defied all efforts made to isolate it, has been recognized by Dr. Osborn. "Liberated fluorine" from cryolite, we are informed incidentally, attacked clay crucibles to such a degree that the use of cryolite had to be abandoned at the American Steel Works, Brooklyn!

The book is also sadly deficient in regard to recent improvements in the manufacture of iron. On the important subject of coking, we have, in addition to Overman's work, nothing but the single method used at the Cambria Works, Pa., for coking in heaps. The large number of coking furnaces that have come into use in the last twenty years have been completely ignored. On roasting of ores we have, in the way of novelty, merely the three methods of illustrations, given in Petitgand & Ronna's appendix to the French translation of Percy. The many new forms of roasting-kilns in which waste gases are used are entirely omitted. Westman's kilns, introduced into this country by Mr. Hewitt, might have been at least mentioned, as the book has "special reference to American materials and processes."

Steel is discussed and dismissed in 57 pages. We find here no reference to the Siemens-Martin process, and the Bessemer process as practised in America is not once mentioned.

In fact, one would infer from Osborn's book that the manufacture of iron and steel, since Overman's treatise was published, had been practically at a stand-still. An attempt has been made, it is true, to bring that work up to date, but with so little care, industry, and research, that the new book is hardly better than the old.

We feel that such a work as this cannot be severely enough condemned. Reviving a bad book that should have been allowed to remain in oblivion, and taking it as a groundwork, the author has added but little that is useful and much that is false, the whole being written in a most incoherent, slovenly style.

THE PNEUMATIC SEWAGE SYSTEM TREATED WITH REFERENCE TO PUBLIC HEALTH, AGRICULTURE, AND NATIONAL ECONOMY. By Dr. G. ZEHFUSS. Translated by Dr. F. COAR, of Philadelphia. With an introduction to Captain CHAS. T. LIERNUR'S "Pneumatic Sewage System." Cologne. 1869. For sale by Van Nostrand.

Besides the subjects enumerated in the title, this pamphlet describes the sewage systems employed in different countries, and estimates their relative sanitary and economical values.

The Pneumatic System here proposed for large towns is certainly very complete in its design.

THE DRY EARTH SYSTEM. By H. J. & J. W. GIBDLESTONE. London: E. & F. N. SPON. 1869. For sale by Van Nostrand.

This is an able elucidation of the merits of the earth closet, already somewhat familiar to people of this country.

A TREATISE ON ROLL-TURNING FOR THE MANUFACTURE OF IRON. By PETER TUNNER, Member of the Austrian Ministry of Mines. Translated and adapted by JOHN B. PEARSE, Metallurgist Engineer and Manager at the Works of the

Pennsylvania Steel Company. New York : D. Van Nostrand Publisher.

The subject of roll-turning has been so scantily treated in all the books which have described the manufacture of iron that very little that is useful can be gleaned from their pages. None of the late books on the subject contain more information than was given by Karsten in 1841, though since that time extraordinary progress has been made in the art.

The chief ground of this neglect of this vital branch of industry is, in my opinion, to be found in the fact that those who have lately written on iron metallurgy have not, as a rule, been practical metallurgists, but only metallurgical chemists, and, therefore, they have neglected as trivial such things as *passes*, or, perhaps, have even held it beneath their dignity to write about them.

The translator has added many practical and valuable suggestions to the work. The text is illustrated by upwards of 40 wood-cuts, and an atlas of ten large folio plates.

IRON TRUSS BRIDGES FOR RAILROADS. Methods of calculating strains, with a comparison of the most prominent Truss Bridges, and new formulas for bridge computations ; also the economical angles for struts and ties. By Brevet-Col. WM. E. MERRILL, U. S. A. New York : D. Van Nostrand.

It is impossible to overrate the importance of a clear understanding of this subject, especially by railway engineers.

As iron and steel supersede wood in bridge construction, and spans are increased beyond all former precedent, the necessity for economy in use of material, and for a proper distribution of it, is greater than ever.

The custom is by far too common to build a truss bridge without regard to proportionate strains. Some empirical formula by application of which the greatest forces are met, is made to do service for all like parts of the same structure. In this way wooden bridges, like the Burr, Howe, and Town's Lattice, are overloaded with timber at the centre, or else poorly supplied with material at the ends. The rude formulas by which these moderate spans were made safe had been made so by the corrections gradually suggested by previous disasters.

Now that there is a growing ambition to accomplish clear spans of 500 or 600 feet, it is more than ever necessary to investigate the nature and amount of the forces to be met.

Col. Merrill's book affords, by easy mathematical processes, the most satisfactory methods of determining the forces residing in the various parts of our leading varieties of American Truss Bridges. His analyses include the Bollman, Fink, Post, Linnville, Murphy-Whipple, and the Triangular bridges.

The book is of quarto form and well illustrated.

A HAND-BOOK OF PRACTICAL TELEGRAPHY. By R. S. CULLEY, Engineer to the Electric and International Telegraph Company. Published with the sanction of the Chairman and Directors of the Electric and International Telegraph Company, and adopted by the Department of Telegraphs for India. Fourth edition revised and enlarged. New York: D. Van Nostrand. publisher.

This is a thoroughly scientific treatise, but may be read with ease and profit by the most unscientific reader.

The author begins with the rudimentary phenomena of electricity, but embraces within the limits of his treatise some of the most intricate problems of practical telegraphy.

The theory and practice of detecting faults in submarine cables will prove especially interesting to the general scientific reader.

WHAT ARE THE STARS? or a Treatise on Astronomy for the Young. By M. E. STOREY LYLE. London : SAMPSON LOW, SON & MARSTON. 1870. For sale by Van Nostrand.

Within the last two years three or four books have appeared designed to aid the student in astronomy in tracing the constellations.

The volume before us is the most attractive-looking star guide we have ever seen, and, judging from its abundance of illustrations, we should think it quite as serviceable as the best of its predecessors.

It is a 16mo volume, and contains 100 engravings.

HAND-BOOK OF PHYSICAL GEOGRAPHY. By KEITH JOHNSTON, JR., F. R. G. S. Edinburgh and London : W. & A. K. JOHNSTON. 1870. For sale by Van Nostrand.

A brief outline of the science of physical geography is presented in this little work. It is evidently designed for beginners. The outlines of the whole subject are well presented, and in a neat and comparatively inexpensive volume.

No diagrams or maps are given in the book.

A NEW SYSTEM OF VENTILATION, which has been thoroughly tested under the patronage of many distinguished persons, being adapted to parlors, dining rooms, sleeping rooms, kitchens, basements, cellars, vaults, school and court rooms, prisons, hospitals, restaurants, coal mines, ships, steamboats, etc., etc.

A book for the household.

Third edition, enlarged with new illustrations by HENRY A. GOUGE. New York: D. Van Nostrand, 1870.

REPORTS ON OBSERVATIONS OF THE TOTAL ECLIPSE OF THE SUN, AUGUST 7th, 1869, conducted under the direction of Commodore B. F. SANDS, U. S. N., Superindendent of the United States Naval Observatory, Washington, D. C. Washington Government Printing Office, 1869. For sale by D. Van Nostrand.

The details of the work, under Government direction, upon the great eclipse, are set forth in a handsome quarto of two hundred pages, and illustrated with twelve photo-lithographs and several wood-cuts.

The completeness of the equipments of the observing parts, and the favorable conditions of position and weather under which the work was accomplished, make the present report a desirable addition to scientific libraries.

NOTICE OF ROEBLING'S BRIDGES. From "Engineering," Jan., 1870.—Not only are the various portions of the structures described, the strains upon every part under varying conditions elaborated, but the weights and costs are figured out to the minutest degree.

In this careful manner several examples of large span bridges are dealt with, and the volume concludes with a page or two of descriptions, and

some designs of short span bridges, in which wire cables are introduced as auxiliary means of support in connection with the trusses.

The whole of the work, brief though it is, bears upon every page the trace of a master in his profession, and of one especially, who, arriving at results in the simplest and most straightforward way, had the power, also, of conveying his ideas clearly.

The book itself is well produced, the engravings beautifully executed, and possessing all the merit of complete working drawings.

A Treatise on Ore Deposits. By Bernhard Von Cotta, Professor of Geology in the Royal School of Mines, Freiberg, Germany, translated from the second German edition by Frederick Prime, Jr., Mining Engineer, revised by the author, with numerous illustrations. New York: D. Van Nostrand, 1870.

The first hundred pages of this valuable work are devoted to a description of the various forms of metalliferous deposits and a discussion of the theories of their formation.

The latter portion of the book, or "special part," as the author terms it, describes minutely the ore beds of Europe, and their geological surroundings.

It is well painted, abundantly illustrated, and is a valuable addition to the literature of economic geology.

The Chemical Forces—Heat, Light and Electricity. With their application to the expansion, liquefaction and vaporization of solids; the steam-engine, photography, spectrum analysis, the galvanic battery, electro-plating, the electrical illumination of light-houses, the fire-alarm of cities, the atlantic telegraph. An introduction to "Chemical Physics." Designed for the use of academies, colleges, and medical schools. Illustrated with numerous engravings, and containing copious lists of experiments, with directions for preparing them. By Thomas Ruggles Pynchon. Hartford: A. S. Hale & Co. 1870. For sale by Van Nostrand.

The recent progress in physical science has created a demand among instructors for more extended treatises upon the above subjects than they have heretofore been able to obtain. The work of Prof. Pynchon seems well adapted to meet such a demand. It is well arranged and copiously illustrated.

MISCELLANEOUS.

Stump Drawing by Steam.—In the neighborhood of Tattershall, in Lincolnshire, are some hundreds of acres of waste land, of a light sandy and gravelly nature, encumbered by the stumps of Scotch fir trees, cut down some years ago, and only growing wild grass and ling. It has been proved, however, by experiments made in a small way, that this land, if properly cleared, drained, and clayed, is capable of bearing good root crops; but, until lately, the great expenditure of labor incidental to extracting the stumps and roots of the fir trees has prevented the work of reclamation from being carried out to any great extent. A short time ago, however, Mr. John Robert Bankes, the agent and steward to Lord Fortescue, to whom the land belongs, determined to attempt drawing the stumps by means of steam ploughing engines; and eventually, after a consultation on the subject with Mr. Toepffer, of the North Lincolnshire Steam Cultivating Company, a contract was entered into by this company to perform the work.

The stumps are from 12 in. to 20 in. in diameter at the base and stand from about 8t. to 10 ft. apart, and the operation of drawing them, which has now been going on successfully for some weeks past, is performed as follows: Two of Messrs. John Fowler & Co.'s 20 horse steam ploughing engines are placed about 200 yards apart, with a row of the tree stumps between them, and, in commencing, the wire rope from the drum of one engine is led across to the second engine, passed round a snatch block there, and led back and attached to the engine from the drum of which it was uncoiled. The snatch block just mentioned is connected by a strong chain to a two-fluked anchor of a form suitable for taking hold of the stumps, and to a chain at the back of the anchor is attached the rope of the second engine. Things being thus arranged, the anchor, which is, as it were, suspended between the engines, is raised by four men and placed about 2 ft. in the rear of the first stump to be extracted. The engine connected with the snatch block is then made to haul upon its rope, when the anchor is drawn into the ground, takes hold of the stump, and extracts it with the utmost ease. As soon as the root is clearly pulled up, the second engine hauls back the anchor to clear it, and all is then ready for acting on another stump. When fairly at work, the drawing of the stumps is performed at the rate of 1 per minute.

The pull which each engine is capable of exerting on the rope is about 8 tons, so that, by the aid of a single snatch block, a pull of 16 tons can be exerted, or by means of a double snatch block a pull of over 30 tons. The double snatch block, however, is only required for the largest stumps. Besides the two 20-horse engines, two others of less power are engaged in drawing the extracted stumps into heaps, and thus clearing the land for ploughing. The whole operation has, as we have said, been thoroughly successful, and all parties concerned are to be congratulated on opening up a new and useful field for the employment of steam ploughing engines.—*Engineering.*

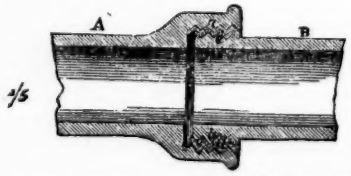
Chinese Engineering Art.—China is by no means a progressive country, either in arts or sciences, but several of the industrial methods pursued by her people are unique and curious, and some of them are worthy of imitation in principle, if not literally. Of these there are two precautions adopted in working the mines of coal, which are tolerably numerous in the Celestial Empire: "1. Whenever gas of a mephitic or inflammable character is encountered in the pits, a bamboo tube is introduced throughout the various workings, terminated at the lower extremity by a conical point. This is inserted in the fiery or dangerous seam, and the gas conducted away to the external atmosphere. 2. A timber framework is erected occasionally to support the roof, but only for so long as it is required to maintain a free passage underneath. When there is no further necessity for it, the general practice is to fill up the excavated spaces by earth well rammed in and consolidated. All 'creeps and falling in the roof are thus avoided.'"

The Chinese have no industrial use for salt; but

of course, they require it for seasoning and preserving articles of food. Some salt is obtained from mines o f rock salt, some from brine wells. "A simple but rather ingenious method is employed for raising the salt liquid from the wells. A long bamboo is hollowed out, and a valve, opening inwards, is fixed to the lower end. This is lowered down and sunk into the liquid, which rises through the valve. As soon as the bamboo is considered to be full it is hauled up, the pressure of the contained fluid keeping the valve close. In one particular province of China the salt pits are not free from an inflammable gas. This is utilized for heating the boilers in which the saline liquid is evaporated, thus proving that the natives have an eye to the economy of fuel. The boilers are erected near the pits, and the gas brought to them in bamboo tubes, furnished with a copper burner. In the northern portions of the empire salt is used for preserving and embalming the bodies of defunct mandarins and officials of high position."

Vessels for containing oils and varnishes which corrode metals, wood, etc., are made by the Chinese as follows: "An open carcass or frame is made of small pieces of bamboo closely entwined. The interior of the carcass is lined with paper, manufactured also from a bamboo of an inferior quality, and is caused to adhere to the frame by a particular description of paste, prepared from a mixture of flour and a hot and strong solution of gelatine. This lining is covered by a layer of mastic composed of lime, sand, and a paste made from peas. When it is dried it is in its turn covered with paper, and the vessel is complete and ready for sale."—*Engineering.*

A New Pipe-Joint.—M. Fragneau has invented a method of joining pipes which he claims to be superior to the ordinary method, in economy, convenience, and efficiency.



The figure represents a longitudinal section of one of these joints. Inside the ends of A and B are cast corresponding screw threads, male and female. The diameters differ by an amount sufficient to admit of the following operation:

A copper mould, with a carefully-turned thread, is inserted in A at the joint, so as to allow of casting upon it a thin ring of lead, *a*, which adapts itself to the thread of the casting. A similar ring, *c*, is cast upon the extremity of B. These rings should be slightly conical, and of such thickness that both will well fill the space *b d*. The parts should be well greased with a mastic of plumbago and tallow. When the parts are screwed home, the joint will be hermetically closed.

The operation is performed quickly, and requires no special precaution or skilled laborers. It is also economical of lead, a fact that makes it superior to the ordinary method.

The lead rings may be cast separate, if desired, and then slipped upon the ends. Again, a single lead ring may be employed. This method of jointing is applicable to tubes of all dimensions and of all angles.—*Condensed from Le Génie Industriel.*

Heat Paradox.—Mr. Spence has made public an apparent paradox in the science of heat, whereby he is enabled to raise a higher temperature in certain solutions by steam of 212 degs. Fahr. He selected a solution of a salt (nitrate of soda) having a high boiling-point, about 250 degs. Fahr. The nitrate of soda was placed in a vessel surrounded by a jacket; steam was let into the intervening space until a temperature of nearly 212 degs. Fahr. was obtained; the steam was then shut off and an open pipe immersed in the solution, and steam from the same source was thrown directly into the liquor; in a few seconds the thermometer slowly, but steadily, moved, and, minute after minute, progressed until it touched 250 degs. Fahr. This unexpected fact has become to the author of great practical value. As a corroboration of the theory which seems to explain the apparent paradox, the author finds that the temperatures of his solutions are in the exact ratios of their specific gravities, and have no connection with the temperature of steam, which never exceeds 212 degs. Fahr. The greater the specific gravity of his solutions, the higher the boiling-point; and, therefore, whatever the boiling-point of the solution in water of any salt, to that point, or nearly, will steam of 212 degs. Fahr. raise it.—*Quarterly Journal of Science.*

Glue which will Unite Polished Steel.—The following is a Turkish receipt for a cement used to fasten diamonds and other precious stones to metallic surfaces, and which is said to be capable of strongly uniting surfaces of polished steel, even when exposed to moisture. It is as follows:—Dissolve five or six bits of gum mastic, each the size of a large pea, in as much spirit of wine as will suffice to render it liquid. In another vessel dissolve in brandy as much isinglass, previously softened in water, as will make a two-ounce phial of strong glue, adding two small bits of gum ammoniac, which must be rubbed until dissolved. Then mix the whole with heat. Keep in a phial closely stopped. When it is to be used set the phial in boiling water.—*The Stationer.*

Temperature of the Sea.—The thermometers employed for measuring deep sea temperature, and used throughout the "Porcupine" dredging expedition, were of a pattern invented for the purpose by Professor Miller, and made by Mr. Cassella. In all previous researches of the kind ordinary thermometers have been used, and these are not only very liable to fracture, but they also rise under pressure, and the readings from them require correction on this account. The Miller-Cassella thermometer, on the other hand, was tested under a pressure of 3 tons to the square inch (corresponding to that of an ocean depth of 2,400 fathoms), prior to the departure of the expedition, and showed no more change than a rise of about 1 degree, which was due to the actual increment of heat arising from the pressure itself; while so strong were the instruments that two of them were in constant use, without injury, throughout the whole of the expedition. The temperature was taken both by serial and by bottom soundings; the former being repeated every

50 fathoms, or even more frequently, down to a depth of 300, and every 100 fathoms at greater depths. The surface temperature varied a good deal with the differences of latitude and season; but, when high, declined rapidly, and was lost at about 100 fathoms. From hence, in deep water, there was a rapid decline to about 1,000 fathoms, at which a temperature of about 38 deg. was found; and at 2,435 fathoms there was a slight further fall to 36.5 deg. Compared with this comparatively elevated temperature, it has been found that the deep sea temperature in the Arabian Gulf, and even under the equator, is very low, falling to about 30 deg., or even lower; so that the general temperature of the deep tropical seas is less than that of the North Atlantic basin. On the other hand, the bottom temperature of certain parts of the channel between the Faroe Islands and the north of Scotland, sunk to as low as 30 deg., while at the same depth in adjacent localities it was as high as 43 deg. In the colder area it was found that the temperature fell rapidly between 150 and 300 fathoms, to remain almost stationary below the latter depth; and the general result of the thermometric observations was to show the existence of a stratum of ice-cold water from 300 fathoms downwards; a stratum of warm water for about 150 fathoms from the surface, and a stratum of intermixture between the other two. The cold area occupied nearly the whole of the actual channel between the Faroe Islands and Scotland; but a higher bottom temperature was found along the east side of this channel, near the so-called 100 fathoms line, which marks the commencement of the ascent to that plateau of which the surfaces form the British Islands.—*The Engineer.*

VARNISH FOR IRON.—The following is a method given by M. Weiszkopf, of producing upon iron a durable black shining varnish:—"Take oil of turpentine, add to it, drop by drop and while stirring, strong sulphuric acid until a syrupy precipitate is quite formed, and no more of it is produced on further addition of a drop of acid. The liquid is now repeatedly washed with water, every time refreshed after a good stirring, until the water does not exhibit any more acid reaction on being tested with blue litmus paper. The precipitate is next brought upon a cloth filter, and, after all the water has run off the syrupy mass is fit for use. This thickish magma is painted over the iron with a brush; if it happens to be too stiff, it is previously diluted with some oil of turpentine. Immediately after the iron has been so painted, the paint is burnt in by a gentle heat, and, after cooling, the black surface is rubbed over with a piece of woollen stuff dipped in and moistened with linseed oil. According to the author, this varnish is not a simple covering of the surface, but it is chemically combined with the metal, and does not, therefore, wear off or peel off, as other paints and varnishes do, from iron."

A NEW METHOD OF CASTING METALS.—Until recently there has been for a long time no material improvement in the methods and processes of casting metals. Moulds of sand into which the molten metal is poured, producing a rough casting, requiring to be finished by hand, is the process which, for generations, has been in general use. The nicer and better kinds of work involve a large expense in the labor of finishing after the casting is taken from the mould, and there is a very large number and variety of metallic articles, both of an artistic and economic character, which could not be cast at all, but each had to be wrought separately by the slow and tedious process of the engraver.

The recent inventions of Charles and Michael Smith, introduced with complete success into practical operation by the Metallic Compression Casting Company at their foundry in Somerville, near Boston, promise to result in an entire revolution in the metallurgic art, so far as casting is concerned.

By the process covered by the patents of the Messrs. Smith, the metal is taken from the mould, not with a rough surface, as in all the heretofore known modes of casting, but as smooth and perfectly finished as a coin or medal struck by a die, and this at no considerable addition to the cost of casting by the old process. It is true that almost every step in the process as invented by the Messrs. Smith, is totally different from the old, but at no greatly enhanced cost.

The company are now actually at work producing for the market, house and car trimmings, such as knobs, hinges, escutcheons, bell pulls, dies for printing wall paper, and for bookbinders, and a variety of articles which, until these inventions, could be produced by hand, but by the new processes are turned out with equal if not greater facility as common rough castings.

Experiments entirely successful have been made in casting stereotype plates, printing types, medallion heads of Corneille, Schiller, Gœthe, and a copy of the famous Wellington medal, the dies for which occupied the artist 11 years in their execution. The copy cast by the Compression Casting Company came from the mould as perfect in finish as if struck by the original die. These experiments show that, no matter how delicate or elaborate the style of the work, it can be cheaply and with perfect accuracy produced by this process. Two specimens of work seem conclusively to establish these facts—one a bas relief representation of the battle of Bunker Hill, after Trumbull's famous picture, containing over fifty figures, originally modelled in wax, cast in hard metal by Mr. Smith by the compression process. Several leading European founders declined the work, the artist requiring a guaranty of payment of $5,000, the value of the model, in case of injury. The other was a specimen of the wheels used in cancelling stamps, with the edges lettered and figured. The moulding of these wheels excites the admiration of the spectator, as he observes the simplicity and efficiency of the work and the satisfactory character of the result.—*Exchange.*

ACTION OF SUNLIGHT ON SULPHUROUS ACID.—We know that plants, under the influence of the sunlight reduce within their substance carbonic acid and water to organic compounds and organized tissues. We know further, that the albuminous parts as well as some essential oils of plants contain sulphur, which doubtless comes from the sulphates contained in the soil.

As regards this reduction of sulphuric acid in the plants, it seemed to me of some interest to try whether the sunlight possesses any reducing power upon the oxygen compounds of sulphur outside of vegetable tissues. For this purpose I exposed diluted sulphuric acid, solutions of sulphates, sulphites, and aqueous sulphurous acid, under various conditions, in sealed tubes, to the

sunlight of last summer. With sulphurous acid only did I notice any change; and even the tubes containing this remained *clear during two months*, but after that time a change set in which slowly increased, and sulphur was deposited in a finely divided state.

Sulphurous acid was thus gradually reduced to sulphur, but *oxygen was not liberated;* another part of the acid having been oxidized by it to sulphuric acid. It seems very singular that such a period (two months) was required to initiate this change; and it would appear that a previous absorption of a great amount of light was necessary to the separation of the first atom of sulphur, which was followed then, however, by more atoms at shorter intervals.—*American Gas Light Journal.*

PHILOSOPHICAL SOCIETY OF GLASGOW.—CHEMICAL SECTION.—At a meeting of the section an interesting paper was read by Mr. W. R. Hutton, manufacturing chemist, on "The Chemistry of Coal Smoke." Mr. Hutton's object was to direct attention to the chemical ingredients of smoke as determined by the analysis of soot, and to suggest a means of thoroughly avoiding the production of smoke, both in domestic fireplaces and in ordinary steam-boiler furnaces. Very elaborate analyses of London and Glasgow soot were given. Tar and oil were found to the extent of from 15 to 18 per cent., 2.8 per cent. ammonia, from 4.6 to 7.9 per cent. of sulphuric acid, and from 14.4 (in London soot) to 25.7 (in Glasgow soot) of sand. It was not improbable that the last-mentioned ingredient was present, in part at least, as an adulterant. Mr. Hutton expressed himself strongly in favor of distilling the raw coal before using it as fuel, and stopping the distillation shortly before the volatile matter is all removed. There would thus be left what Mr. Hutton calls *soft coke*, containing all the fixed carbon, the ash, and enough of volatile matter to render the coke inflammable, but not to produce soot. The author assumed the case of a town consuming 2,000 tons daily, and said that if the coal were distilled before being used as fuel, as he suggested, there would be produced about 1,400 tons of soft coke, 40,000 gallons of crude oil, 30,000 gallons of ammoniacal water, and 6,000,000 cubic feet of hydrocarbon gas. Taking the coal at 5s. per ton, and the labor at 1s. per ton, there would be a clear gain of £142, as the coke would have the same heating power and therefore the same value as the raw coal, while the crude oil would bring £167, and the ammoniacal water £75 additional.—*Engineering.*

QUICKSILVER AND IRON.—The difficulty of imparting to iron a complete and uniform coating of mercury by dipping it in a solution of mercury is well known. The process may, however, be very easily accomplished by cleaning the iron first with hydrochloric acid, and then immersing it in a diluted solution of blue vitriol mixed with a little hydrochloric acid, by means of which it becomes covered with a slightly adherent layer of copper, from which it must be freed by brushing, or rubbing with sand paper and washing. It is then to be brought into a diluted solution of mercurial sublimate mixed with a few drops of hydrochloric acid. The article will now be covered with a layer of mercury, which cannot be removed even by hard rubbing. This layer of quicksilver protects the iron from rust, especially if it be washed with spirits of salammoniac after the amalgamation. Articles for the laboratory, and for other purposes, coated with quicksilver in this way, and allowed to be exposed with similar articles not so protected, retain their lustre perfectly, while the others become covered with rust. This same process is especially applicable to the coating of the steel or iron instruments for which oil is generally employed, and will probably be found to resist the injurious effect of moisture much more perfectly than the oil.—*Iron Age.*

EFFECT OF SUNLIGHT ON GLASS.—M. Bontemps, the managing director of the celebrated crystal glass works of Choisy-le-Roi, says: "Within three months after exposure to sunlight, the best and whitest glass made at St. Gobain is turned distinctly yellow; extra white glass (of a peculiar manufacture) becomes even more yellow, gradually assuming a color known as *pelure d' oignon;* glass containing 5 per cent. of litharge is also affected, but far less perceptibly; crystal glass made with carbonate of potassa (the other varieties referred to contain carbonate of soda), litharge, and silica, is not at all affected. English plate-glass, made by the British Plate-Glass Company, and exhibiting a distinctly azure-blue tinge, remains also unaffected. The author attributes this coloration, which begins with yellow and gradually turns to violet, to the oxidizing effect of the sun's rays upon the protoxides of manganese and iron contained in the glass.—*Quarterly Journal of Science.*

OXYGEN GAS.—The manufacture of oxygen gas on a commercial scale is increasing in Paris. Mr. Fowler, who has described one of the factories, says that 500 pounds of manganate of soda furnish 2½ cubic yards of oxygen every hour. The charge is placed in a retort and superheated—steam passed over it; in five minutes all the oxygen is extracted from this quantity of the salt. Hot air passed over this residue for five more minutes restores all the oxygen given up, and the result of an hour's continuous work, or six extractions of oxygen and six re-oxidations, is 2½ cubic yards of oxygen. This oxygen, when it issues from the gasometers, contains about 15 per cent. of nitrogen; but, by letting the first portions escape, the quantity of this mixture can be reduced to 2½ per cent. M. du Mothay affirms that one ton of manganate of soda will yield 100 cubic yards of oxygen daily, or more than 36,000 per year; and this without having to renew the salt once.—*Quarterly Journal of Science.*

THE MOON'S HEAT.—According to M. Baille, the moon's surface emits as much heat as a cube filled with water, covered with lamp-black, having a surface of 6.5 square centims., and placed at a distance of 35 metres from the thermo-electric apparatus employed by the author in his experiments.

CIVIL ENGINEERING IN AMERICA IN 1831.—When it was proposed in 1831 to build a railroad from East Boston to Salem there was not a civil engineer in Massachusetts of sufficient practical knowledge to make a survey. Lieutenant Vinton, of the United States Artillery, stationed at Fort Independence, was detailed for the duty.

ERRATUM.—On page 234, 21st line from bottom, instead of "Bajle," read "Bogie."